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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 555

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. ▲ November 26, 1917

# STANDARD FORMS FOR SPECIFICATIONS, TESTS, REPORTS, AND METHODS OF SAMPLING FOR ROAD MATERIALS

As recommended by the

FIRST CONFERENCE OF STATE HIGHWAY TESTING ENGINEERS AND CHEMISTS

Washington, D. C., February 12 to 17, 1917

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**As Recommended by the First Conference of State Highway Testing Engineers and Chemists, Washington, D. C., Feb. 12–17, 1917.**

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## INTRODUCTION.

With the joint participation of the Federal Government and States in the construction of highways under the Federal aid road act of July 11, 1916, it became necessary for the United States Office of Public Roads and Rural Engineering to familiarize itself thoroughly with the practice of different States in highway work in order to facilitate perfect cooperation. The construction of highways may be considered under two main headings: (1) Materials used and (2) methods used. The report of this conference has to do with the first subject.

As a result of a canvass of the various States made by circular letter in the latter part of 1916, it was ascertained that less than one-half of the States had proper facilities for testing materials used by them in highway work, and many had no facilities at all. At that time a large majority of the States indicated their willingness to cooperate with the Office of Public Roads and Rural Engineering and, if possible, to send representatives to attend a conference upon the subject of materials used in highway work. After the conference had been called it was found that many of the States which had signified their willingness to cooperate could not send representatives at the time appointed. However, a widespread interest in the

work of the conference was expressed, and numerous requests were received for copies of the report of the conference. Under existing conditions and the general difficulty of securing representatives from all parts of the country to meet at a given point, it is considered highly gratifying that 26 representatives from 21 States attended.

Because it was felt that a sufficient number of permanent organizations having to do with highway matters now exist, no additional permanent organization was contemplated, but the Office of Public Roads and Rural Engineering proposes to call other conferences from time to time as they may be needed. It is not intended to conflict or compete in any way with the permanent organizations, and, in fact, it is suggested that the conferences adopt the standards of such organizations whenever they are considered reasonably satisfactory.

The purposes of the conference announced in advance were as follows:

(1) To encourage the establishment of well-equipped State highway laboratories.

(2) To recommend for general adoption standard forms of specifications for various types of road materials as applied to specific uses.

(3) To recommend for general adoption a comprehensive set of standard tests for various types of road materials.

(4) To recommend for general adoption uniform methods of reporting test results of various types of road materials.

(5) To recommend for general adoption standard methods of sampling and inspecting various types of road materials.

(6) To outline a plan of cooperative research on the part of the States in connection with the value of physical and chemical tests of various types of road materials as related to their use.

(7) To recommend methods whereby the maximum efficiency of the laboratory may be developed as well as its maximum usefulness to highway engineers.

It was realized that lack of time would prevent the first conference from considering all materials of interest in highway engineering. Therefore its attention was confined to recommendations relating to specifications, testing, sampling, and reporting tests on those materials which are included in this report. It is hoped to cover other materials at later conferences.

In the following report the recommendations of the conference are presented in four sections:

(1) Standard forms of specifications for materials.

(2) Standard methods of testing materials.

(3) Standard forms of reporting test results.

(4) Standard methods of sampling materials.

In the standard forms of specifications such tests as are considered necessary have been included, but, as a rule, specific test limits have not been recommended, owing to recognition of the fact that no one set of test limits could cover satisfactorily the wide differences in methods of construction, available materials, and local conditions peculiar to the various parts of the country. It is expected that engineers who adopt the recommended forms of specifications will insert such test limits as they consider advisable for any given work.

Under standard methods of testing references only are given for description of tests which are published in readily available form. This is also true of the methods of sampling.

LOGAN WALLER PAGE,
*Director Office of Public Roads and Rural Engineering.*

## RECOMMENDED STANDARD FORMS OF SPECIFICATIONS FOR MATERIALS.

### SPECIFICATION FOR BROKEN STONE FOR WATERBOUND MACADAM.

**General.**

The broken stone shall consist of angular fragments of (insert types allowable), of uniform quality throughout, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter.

**Physical properties.**

The stone shall meet the following requirements:

| | |
|---|---|
| Per cent of wear | ____ to ____ |
| (*or* French coefficient | ____ to ____) |
| *Toughness | ____ to ____ |
| *Hardness | ____ to ____ |
| *Absorption | not more than ____% |

**Screenings or No. __ stone.**

That portion of the product of the crusher, including the dust of fracture, which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing ____-inch screen | 100 |
| Total passing ____-inch screen | ____ to ____ |

**Top course or No. __ stone.**

That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing ____-inch screen | 100 |
| Total passing ____-inch screen | ____ to ____ |
| Retained on ____-inch screen | 100 |

**Bottom course or No. __ stone.**

That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing ____-inch screen | 100 |
| Total passing ____-inch screen | ____ to ____ |
| Retained on ____-inch screen | 100 |

**Method of sampling.**

Stone shall be sampled for quality and size in accordance with the method described on page ____, paragraphs ____, of these specifications.

**Methods of testing.**

Tests of the physical properties and sizes of the stone shall be made in accordance with the methods described or referred to on pages ____ of these specifications, tests Nos. ____.

### SPECIFICATION FOR BROKEN STONE FOR BITUMINOUS MACADAM.

**General.**

The broken stone shall consist of angular fragments of (insert types allowable), of uniform quality throughout, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter occurring either free or as a coating on the stone.

* Tests recommended by the conference which it may be desirable to omit in some instances.

**Physical properties.** The stone shall meet the following requirements:

Per cent of wear_____not more than _____
(*or* French coefficient_____not less than _____.)
*Toughness_____not less than _____
*Hardness _____not less than _____
*Absorption_____not more than ____%

**Chips or No. __ stone.** That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen_____ | 100 |
| Total passing _____ inch screen_____ | _____ to _____ |
| Retained on _____ inch screen_____ | 100 |

**Top course or No. __ stone.** That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen_____ | 100 |
| Total passing _____ inch screen_____ | _____ to _____ |
| Retained on _____ inch screen_____ | 100 |

**Bottom course or No. __ stone.** That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen_____ | 100 |
| Total passing _____ inch screen_____ | _____ to _____ |
| Retained on _____ inch screen_____ | 100 |

**Method of sampling.** Stone shall be sampled for quality and size in accordance with the method described on page _____, paragraphs _____, of these specifications.

**Methods of testing.** Tests of the physical properties and sizes of the stone shall be made in accordance with the methods described or referred to on pages _____ of these specifications, tests Nos. _____.

## SPECIFICATION FOR BROKEN STONE AGGREGATE FOR LARGE AGGREGATE BITUMINOUS CONCRETE.

**General.** The broken stone aggregate shall consist of angular fragments of (insert types allowable), of uniform quality throughout, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter, occurring either free or as a coating on the stone.

**Physical properties.** The stone shall meet the following requirements:

Per cent of wear_____not more than _____
(*or* French coefficient_____not less than _____.)
*Hardness _____not less than _____
*Toughness _____not less than _____
*Absorption_____not more than ____%

**Grading.** The broken stone aggregate, when tested by means of laboratory screens, shall meet the following requirements:

* Tests recommended by the conference which it may be desirable to omit in some instances.

| | Per cent. |
|---|---|
| Passing (the largest size selected) inch screen | 100 |
| Passing (the largest size selected) inch screen and retained on (the second largest size selected) inch screen | ------ to ------ |
| Passing (the second largest size selected) inch screen and retained on (the third largest size selected) inch screen | ------ to ------ |
| Passing (the third largest size selected) inch screen and retained on (the fourth largest size selected) inch screen | ------ to ------ |
| *Passing, etc | |

Method of sampling.

Stone shall be sampled for quality and grading in accordance with the method described on page ------, paragraphs ------, of these specifications.

Methods of testing.

Tests of the physical properties and grading of the stone shall be made in accordance with the methods described or referred to on pages ------ of these specifications, tests Nos. ------.

## SPECIFICATION FOR COARSE AND FINE AGGREGATE FOR LARGE AGGREGATE BITUMINOUS CONCRETE (BROKEN STONE OR SAND).

### Broken Stone for Coarse Aggregate.

General.

The broken stone for coarse aggregate shall consist of angular fragments of (insert types allowable), free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter occurring either free or as a coating on the stone.

Physical properties.

The stone shall meet the following requirements:

Per cent of wear ------ not more than ------
(*or* French coefficient ------ not less than ------.)
† Hardness ------ not less than ------
† Toughness ------ not less than ------
† Absorption ------ not more than ----%

Grading.

The broken stone for coarse aggregate, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing (the largest size selected)-inch screen | 100 |
| Passing (the largest size selected) -inch screen and retained on (the second largest size selected) -inch screen | ------ to ------ |
| ‡Passing, etc | |

Method of sampling.

Stone shall be sampled for quality and grading in accordance with the method described on page ------, paragraphs ------, of these specifications.

---

* The number and size of screens and sieves may be continued as desired by the engineer. For 10-mesh sieve and finer the wording should be: Passing ------ mesh sieve and retained on ------ mesh sieve ------ to ------. The last requirement should be: Passing ------ inch screen (or mesh sieve) not more than (or not less than) ------.

† Tests recommended by the conference which it may be desirable to omit in some instances.

‡ The number and sizes of screens may be continued as desired by the engineer. The last requirement should be: Passing 1/4-inch screen, not more than ------.

**Methods of testing.** Tests of the physical properties and grading of the stone shall be made in accordance with the methods described or referred to on pages _____ of these specifications, tests Nos. _____.

BROKEN STONE OR SAND FOR FINE AGGREGATE.

**General.** The fine aggregate shall be composed of sound, durable particles of stone or sand. The particles shall be free from a coating of clay or loam.

**Grading.** The broken stone or sand for fine aggregate, when tested by means of laboratory screens and sieves, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing 1/4-inch screen_____not less than | _____ |
| Passing 1/4-inch screen and retained on 10-mesh sieve_____ | _____ to _____ |
| Passing 10-mesh and retained on 40-mesh sieve _____ | _____ to _____ |
| Passing 40-mesh and retained on 200-mesh sieve _____ | _____ to _____ |
| Passing 200-mesh sieve_____not more than | _____ |

**Methods of sampling and grading.** Stone or sand shall be sampled for grading in accordance with the methods described on page _____, paragraphs _____, of these specifications, and tests of grading shall be made in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

## SPECIFICATION FOR COARSE AND FINE AGGREGATE FOR TOPEKA TYPE BITUMINOUS CONCRETE (BROKEN STONE OR SAND).

BROKEN STONE FOR COARSE AGGREGATE.

**General.** The broken stone for coarse aggregate shall consist of angular fragments of (insert types allowable), free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter, occurring either free or as a coating on the stone.

**Physical properties.** The stone shall meet the following requirements:

| | |
|---|---|
| Per cent of wear_____not more than | _____ |
| (*or* French coefficient_____not less than | _____) |
| *Hardness _____not less than | _____ |
| *Toughness _____not less than | _____ |
| *Absorption_____not more than | ____% |

**Grading.** The broken stone for coarse aggregate, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing (the largest size selected) inch screen_ | 100 |
| Passing (the largest size selected) inch screen and retained on (the second largest size selected) inch screen_____ | _____ to _____ |
| †Passing, etc_____ | |

---

* Tests recommended by the conference, which it may be desirable to omit in some instances.

† The number and sizes of screens may be continued as desired by the engineer. The last requirement should be: Passing 10-mesh sieve, not more than _____.

Method of sampling.

Stone shall be sampled for quality and grading in accordance with the method described on page _____, paragraphs _____, of these specifications.

Methods of testing.

Tests of the physical properties and grading of the stone shall be made in accordance with the methods described on pages _____ of these specifications, tests Nos. _____.

### Broken Stone or Sand for Fine Aggregate.

General.

The fine aggregate shall be composed of sound, durable particles of stone or sand. The particles shall be free from a coating of clay or loam.

Grading.

The broken stone or sand for fine aggregate, when tested by means of laboratory sieves, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing 10-mesh sieve—not less than | _____ |
| Passing 10-mesh and retained on 40-mesh sieve | _____ to _____ |
| Passing 40-mesh and retained on 80-mesh sieve | _____ to _____ |
| Passing 80-mesh and retained on 200 mesh sieve | _____ to _____ |
| Passing 200-mesh sieve | _____ to _____ |

Methods of sampling and grading.

Stone or sand shall be sampled for grading in accordance with the method described on page _____, paragraphs _____, of these specifications, and tests of grading shall be made in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

### SPECIFICATION FOR BROKEN STONE OR GRAVEL FOR COARSE AGGREGATE FOR PORTLAND-CEMENT CONCRETE BASE.

General.

The broken stone or gravel aggregate shall consist of clean, hard, tough, durable rock. It shall contain no vegetable or other deleterious matter, and shall be free from soft, thin, elongated or laminated pieces.

Grading.

The broken stone or gravel shall be graded from coarse to fine, and when teseted by means of laboratory screens shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen | 100 |
| Passing _____ inch screen—not more than | _____ |

Methods of sampling and grading.

Broken stone or gravel shall be sampled for grading in accordance with the method described on page _____, paragraphs _____, of these specifications, and tests of grading shall be made in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

### SPECIFICATION FOR BROKEN STONE FOR COARSE AGGREGATE FOR PORTLAND-CEMENT CONCRETE WEARING SURFACE.

General.

The broken stone aggregate shall consist of fragments of clean, hard, tough, durable rock. It shall contain no vegetable or other deleterious matter, and shall be free from soft, thin, elongated, or laminated pieces.

**Physical properties.** The stone shall meet the following requirement:

Per cent of wear_____not more than _____
(*or* French coefficient_____not less than _____)

**Grading.** The broken stone, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen_____ | 100 |
| Passing _____* inch screen and retained on _____ inch screen_____ | _____ to _____ |
| Passing _____ inch screen___not more than | _____ |

**Method of sampling.** Stone shall be sampled for quality and grading in accordance with the method described on page _____, paragraphs _____, of these specifications.

**Methods of testing.** Tests of the physical properties and grading of the stone shall be made in accordance with the methods described or referred to on pages _____ of these specifications, tests Nos. _____.

## SPECIFICATION FOR STONE OR GRAVEL SCREENINGS FOR FINE AGGREGATE FOR PORTLAND-CEMENT CONCRETE BASE.

**General.** The screenings shall consist of material obtained by crushing hard, durable rock or gravel, all of which shall pass a revolving screen having circular openings three-eighths of an inch in diameter. They shall be free from lumps of clay and at the time of use from lumps or crusts of hardened material.

**Physical properties.** If the screenings are produced from rock, the rock shall meet the following requirement:

Per cent of wear_____not more than _____
(*or* French coefficient_____not less than _____)

**Grading.** The screenings shall be well graded from coarse to fine and when tested by means of laboratory screens and sieves shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing ¼-inch screen_____not less than | _____ |
| Passing 20-mesh and retained on 50-mesh sieve_____ | _____ to _____ |
| Passing 100-mesh sieve_____not more than | _____ |

**Mortar strength tests.** When that portion of the screenings which passes a one-quarter inch laboratory screen is mixed with Portland cement in the proportions of 1 part of cement to 3 parts of screenings, by weight, according to standard methods of making 1:3 mortar briquets, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least _____† per cent of the strength developed in the same time by mortar of the same proportions made of the same cement and Ottawa sand.

Preliminary acceptance samples shall be subjected to both 7 and 28 day tests and acceptance based thereupon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

**Method of sampling.** Stone shall be sampled for quality in accordance with the method described on page _____, paragraphs _____, of these

* It is recommended that a ¾-inch screen be specified here.

† It is recommended that the minimum strength ratio be 90 per cent for this purpose.

specifications. Stone or gravel screenings shall be sampled for grading in accordance with the method described on page ------, paragraphs ------, of these specifications.

**Methods of testing.**

Tests of the physical properties of stone shall be made in accordance with the method described or referred to on page ------ of these specifications, test No. ------. Tests of the grading of screenings shall be made in accordance with the method described or referred to on page ------ of these specifications, test No. ------.

### SPECIFICATION FOR COMBINATIONS OF DUSTLESS SCREENINGS AND SAND FOR FINE AGGREGATE FOR PORTLAND-CEMENT CONCRETE WEARING SURFACE.

**General.**

The fine aggregate may be composed of a combination of dustless screenings and sand, but shall contain not more than ------* per cent, by volume, of dustless screenings.

The dustless screenings shall consist of material obtained by crushing hard, durable rock, or gravel, all of which when dry shall pass a revolving screen having circular openings three-eighths-inch in diameter. They shall be free from lumps of clay and, at the time of use, from lumps or crusts of hardened material.

The sand shall consist of clean, hard, durable, uncoated particles, preferably siliceous, well graded from coarse to fine, and free from lumps of clay and all organic matter.

**Physical properties, dustless screenings.**

If the dustless screenings are produced from rock, the rock shall meet the following requirement:

Per cent of wear----------not more than ------
(*or* French coefficient----------not less than -----)

**Grading of dustless screenings.**

The dustless screenings shall be well graded from coarse to fine, and, when tested by means of laboratory screens and sieves, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing 1/4-inch screen----------not less than | ------ |
| Passing 20-mesh and retained on 50-mesh sieve---------- | ------ to ------ |
| Passing 100-mesh sieve----------not more than | 5 |

**Grading of mixture.**

The mixture of screenings and sand shall contain no particles which would not pass a revolving screen having circular openings not greater than three-eighths-inch in diameter. When tested by means of laboratory screens and sieves it shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing 1/4-inch screen----------not less than | ------ |
| Passing 20-mesh and retained on 50-mesh sieve---------- | ------ to ------ |
| †Total passing 50-mesh sieve----------not more than | ------ |
| ‡Passing 100-mesh sieve----------not more than | ------ |

Not more than ------ per cent by weight shall be removed by the elutriation test.

---

* The figure 50 is recommended.

† It is recommended that 25 per cent be specified as the amount permitted to pass a 50-mesh sieve.

‡ It is recommended that 5 per cent be specified as the quantity permitted to pass a 100-mesh sieve.

**Mortar strength test.** When that portion of the combined dustless screenings and sand which passes a one-quarter-inch laboratory screen is mixed with Portland cement in the proportion of 1 part of cement to 3 parts of the combination, by weight, according to standard methods of making 1:3 mortar briquets, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least ------* per cent of that developed in the same time by mortar of the same proportions and consistency, made of the same cement and Ottawa sand.

Preliminary acceptance samples shall be subjected to both 7 and 28-day tests, and acceptance based thereupon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

**Methods of sampling.** Stone shall be sampled for quality in accordance with the method described on page ------, paragraphs ------, of these specifications. Dustless screenings and mixtures of the dustless screenings and sand shall be sampled for grading in accordance with the method described on page ------, paragraphs ------, of these specifications; and sand shall be sampled in accordance with the method described on page ------, paragraphs ------, of these specifications.

**Methods of testing.** Tests of the physical properties of stone shall be made in accordance with the method described or referred to on page ------ of these specifications, test No. ------. Tests of the grading of dustless screenings and of the combination of dustless screenings and sand shall be made in accordance with the method described or referred to on page ----- of these specifications, test No. -----.

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NOTE.—It is recommended that volumetric analyses be reported by the laboratory to facilitate field control.

## SPECIFICATION FOR STONE BLOCK.

**General.** The stone block shall be of (insert types allowable), of medium-sized grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams, scales, or disintegrated material.

**Physical properties.** Sample blocks shall meet the following requirements:

| | |
|---|---|
| Per cent of wear | not more than ------ |
| (*or* French coefficient | not less than -----) |
| Hardness | ------ to ------ |

**Dimensions.** The blocks shall meet the following requirements:

| | Inches. |
|---|---|
| Length on top | ------ to ------ |
| Width on top | ------ to ------ |
| Depth | ------ to ------ |

**Visual inspection.** The stone block shall be subjected to inspection subsequent to delivery at the place of use, prior to and during laying, in order to cull out and reject those which fail to conform with the general

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* It is recommended that the strength ratio be 100 per cent for this purpose.

and dimension clauses and the following requirements of this specification.*

The blocks shall be so dressed that when laid as specified measurement of any joint shall show a width of not more than _____ inch for a depth of _____ inches or a width of not more than _____ inch in any part of the joint.

The wearing surface of the blocks shall show no depressions more than _____ inch deep, and the edges and corners shall be unchipped and unbroken.

**Methods of sampling and testing.**

Stone block shall be sampled in accordance with the methods described on page _____, paragraph _____, of these specifications, and tests of physical properties shall be made in accordance with the methods described or referred to on pages _____ of these specifications, tests Nos. _____.

## SPECIFICATION FOR BROKEN SLAG FOR WATER BOUND MACADAM.

**General.**

The broken slag shall consist of angular fragments of (insert types allowable) slag, reasonably uniform in density and quality, free from metallic iron, thin or elongated pieces, dirt, or other objectionable matter.

**Physical properties.**

The slag shall meet the following requirements:

| | |
|---|---|
| Weight per cubic foot | not less than _____ pounds. |
| Per cent of wear | _____ to _____ |
| (*or* French coefficient | _____ to _____) |

**Screenings or No. __ slag.**

That portion of the product of the crusher, including the dust of fracture, which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen | 100 |
| Total passing _____ inch screen | _____ to _____ |

**Top course or No. __ slag.**

That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen | 100 |
| Total passing _____ inch screen | _____ to _____ |
| Retained on _____ inch screen | 100 |

**Bottom course or No. __ slag.**

That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen | 100 |
| Total passing _____ inch screen | _____ to _____ |
| Retained on _____ inch screen | 100 |

**Method of sampling.**

The slag shall be sampled for quality and size in accordance with the method described on page _____, paragraphs _____, of these specifications.

**Methods of testing.**

The tests of the physical properties and sizes of the slag shall be made in accordance with the methods described or referred to on pages _____ of these specifications, tests Nos. _____.

* This sentence has been inserted as a matter of editing, in order to make the requirements conform in principle with the specification for brick recommended by the conference.

### SPECIFICATION FOR BROKEN SLAG FOR BITUMINOUS MACADAM.

**General.** The broken slag shall consist of angular fragments of (insert types allowable) slag, reasonably uniform in density and quality, free from metallic iron, thin or elongated pieces, dirt, or other objectionable matter, occurring either free or as a coating on the slag.

**Physical properties.** The slag shall meet the following requirements:

Weight per cubic foot_____not less than _____ pounds.
Per cent of wear_____not more than _____
(*or* French coefficient_____not less than _____)

**Chips or No. __ slag.** That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____-inch screen_____ | 100 |
| Total passing _____-inch screen_____ | _____ to _____ |
| Retained on _____-inch screen_____ | 100 |

**Top course or No. __ slag.** That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____-inch screen_____ | 100 |
| Total passing _____-inch screen_____ | _____ to _____ |
| Retained on _____-inch screen_____ | 100 |

**Bottom course or No. __ slag.** That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____-inch screen_____ | 100 |
| Total passing _____-inch screen_____ | _____ to _____ |
| Retained on _____-inch screen_____ | 100 |

**Method of sampling.** Slag shall be sampled for quality and size in accordance with the method described on page _____, paragraphs _____, of these specifications.

**Methods of testing.** Tests of the physical properties and sizes of the slag shall be made in accordance with the methods described or referred to on pages _____ of these specifications, tests Nos. _____.

### SPECIFICATION FOR BROKEN SLAG AGGREGATE FOR LARGE AGGREGATE BITUMINOUS CONCRETE.

**General.** The broken slag aggregate shall consist of angular fragments of (insert types allowable) slag, reasonably uniform in density and quality, free from metallic iron, thin or elongated pieces, dirt, or other objectionable matter, occurring either free or as a coating on the slag.

**Physical properties.** The slag shall meet the following requirements:

Weight per cubic foot_____not less than _____ pounds
Per cent of wear_____not more than _____
(*or* French coefficient_____not less than _____)

**Grading.** The broken slag aggregate, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing (the largest size selected) inch screen_ | 100 |

| | Per cent. |
|---|---|
| Passing (the largest size selected) inch screen and retained on (the second largest size selected) inch screen | ------ to ------ |
| Passing (the second largest size selected) inch screen and retained on (the third largest size selected) inch screen | ------ to ------ |
| *Passing, etc | |

Slag shall be sampled for quality and grading in accordance with the method described on page ------, paragraphs ------, of these specifications. **Method of sampling.**

Tests of the physical properties and grading of the slag shall be made in accordance with the methods described or referred to on pages ------ of these specifications, tests Nos. ------. **Methods of testing.**

### SPECIFICATION FOR BROKEN SLAG FOR COARSE AGGREGATE FOR PORTLAND-CEMENT CONCRETE BASE.

**General.** The broken slag aggregate shall consist of fragments of air-cooled (insert types allowable) slag, nonglassy in character, which shall have been exposed to the weather for a period of at least ------† prior to use. It shall be clean, hard, tough, and durable, free from soft, thin, elongated, or laminated pieces, and shall contain no vegetable or other deleterious matter.

**Physical properties.** The slag shall meet the following requirement:

Weight per cubic foot---------- not less than ------ pounds.

**Grading.** The broken slag aggregate shall be graded from coarse to fine, and when tested by means of laboratory screens shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing ------ inch screen | 100 |
| Passing ------ inch screen----------not more than | ------ |

**Method of sampling.** The slag shall be sampled for quality and grading in accordance with the method described on page ------, paragraphs ------, of these specifications.

**Methods of testing.** The tests of the physical properties and grading of the slag shall be made in accordance with the methods described or referred to on pages ------ of these specifications, tests Nos. ------.

### SPECIFICATION FOR GRANULATED SLAG FOR CUSHION.

**General.** The granulated slag shall consist of clean, sharp, gritty particles of water-cooled (insert types allowable) slag, all of which shall pass a ------ inch laboratory screen.

**Methods of sampling and grading.** The granulated slag shall be sampled for quality and size in accordance with the method described on page ------, paragraphs ------, of these specifications; and the tests of its size shall be made in accordance with the method described or referred to on page ------ of these specifications, test No. ------.

---

* The number and sizes of screens and sieves may be continued as desired by the engineer. For 10-mesh sieve and finer the wording should be: Passing ------ mesh sieve and retained on ------ mesh sieve, ------ to ------. The last requirement should be: Passing ------ inch screen (or mesh sieve) not more than (or, not less than) ------.

† The conference recommends that the words "one year" be inserted.

## SPECIFICATION FOR GRAVEL FOR PLAIN GRAVEL ROADS.

**General.** The gravel shall be composed of hard, durable rock, of high resistance to abrasion,* together with sand and clay or other binding material, and shall be free from thin or elongated pieces.

**Grading.** **1.** For base course:

(*a*) The gravel, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing a _____-inch screen____ | 100 |
| Total retained on 1/4-inch screen_ | _____ to _____ |

(*b*) The material retained on the 1/4-inch screen is known as coarse aggregate. The coarse aggregate, when tested by means of a laboratory screen, shall meet the following requirement:

| | |
|---|---|
| Total retained on _____-inch screen _____ | _____ to _____ |

(*c*) The material passing the 1/4-inch screen is known as fine aggregate. The fine aggregate, when tested by means of a laboratory sieve, shall meet the following requirement:

| | |
|---|---|
| Total passing 200-mesh sieve____ | _____ to _____ |

**2.** For wearing course:

(*a*) The gravel, when tested by means of laboratory screens, shall meet the following requirements:

| | |
|---|---|
| Passing a _____-inch screen_____ | 100 |
| Total retained on 1/4-inch screen_ | _____ to _____ |

(*b*) The material retained on the 1/4-inch screen is known as coarse aggregate. The coarse aggregate, when tested by means of a laboratory screen, shall meet the following requirement:

| | |
|---|---|
| Total retained on _____-inch screen _____ | _____ to _____ |

(*c*) The material passing the 1/4-inch screen is known as fine aggregate. The fine aggregate, when tested by

* The conference believes it highly desirable to specify definite test limits for the resistance of gravel to abrasion. The only State which has so far extensively employed an abrasion test for gravel is Ohio. Available test records, therefore, cover only gravels used in that State; and it is felt that sufficient data have not been obtained as yet to warrant the use of an abrasion test clause in the gravel specifications of other States. The conference recommends that individual States make use of the Ohio test for the purpose of establishing limits which may be used later in specifying satisfactory gravels which are available for their highway work. A description of this test will be found on page 30.

Per cent.

means of a laboratory sieve, shall meet the following requirement:

Total passing 200-mesh sieve____ _____ to _____

**Methods of sampling and testing.**

The gravel shall be sampled for quality and grading in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading of the gravel shall be determined in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

### SPECIFICATION FOR GRAVEL AGGREGATE FOR LARGE AGGREGATE BITUMINOUS CONCRETE.

**General.**

The gravel aggregate shall consist of sound, hard, durable rock, of high resistance to abrasion,* and shall contain no particles of shale, slate, coal, or other materials which easily disintegrate. It shall be free from vegetable or other deleterious matter, and shall contain no soft, thin, or elongated pieces.

**Grading.**

The gravel aggregate, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing (the largest size selected) inch screen_ | 100 |
| Passing (the largest size selected) inch screen and retained on (the second largest size selected) inch screen_____ | _____ to _____ |
| Passing (the second largest size selected) inch screen and retained on (the third largest size selected) inch screen_____ | _____ to _____ |
| †Passing, etc_____ | |

**Methods of sampling and grading.**

The gravel shall be sampled for quality and grading in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading shall be determined in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

### SPECIFICATION FOR GRAVEL FOR COARSE AGGREGATE FOR PORTLAND-CEMENT CONCRETE WEARING SURFACE.

**General.**

The gravel aggregate shall consist of sound, hard, durable rock of high resistance to abrasion,* and shall contain no particles of shale, slate, coal, or other materials which easily disintegrate. It shall be free from vegetable or other deleterious matter, and shall contain no soft, thin, or elongated pieces.

---

* The conference believes it highly desirable to specify definite test limits for the resistance of gravel to abrasion. The only State which has so far extensively employed an abrasion test for gravel is Ohio. Available test records, therefore, cover only gravels used in that State, and it is felt that sufficient data have not been obtained as yet to warrant the use of an abrasion-test clause in the gravel specifications of other States. The conference recommends that individual States make use of the Ohio test for the purpose of establishing limits which may be used later in specifying satisfactory gravels which are available for their highway work. A description of this test will be found on page 30.

† The number and sizes of screens and sieves may be continued as desired by the engineer. For 10-mesh sieve and finer, the wording should be: Passing _____ mesh sieve and retained on _____ mesh sieve, _____ to _____. The last requirement should be: Passing _____ inch screen (*or mesh sieve*) not more than (*or not less than*) _____.

**Grading.**

The gravel aggregate, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____ inch screen | 100 |
| Passing _____ inch screen and retained on ¼-inch screen | _____ to _____ |
| Passing 1/4-inch screen_____not more than | _____ |

**Methods of sampling and grading.**

The gravel shall be sampled for quality and grading in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading shall be determined in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

## SPECIFICATION FOR SEMIGRAVEL, TOP-SOIL, OR SAND-CLAY AGGREGATE FOR ROAD SURFACING.

**Definitions.**

The terms *clay, silt, sand,* and *coarse material,* used in this specification, are defined as follows:*

*Clay:* Material separated by subsidence through water and possessing plastic or adhesive properties, generally below 0.01 mm. diameter.

*Silt:* Fine material, other than clay, which passes a 200-mesh sieve, generally from 0.07 to 0.01 mm. diameter.

*Sand:* Hard material, usually siliceous, which passes a 10-mesh sieve and is retained on a 200-mesh sieve, generally from 1.85 to 0.07 mm. diameter.

*Coarse material:* Hard material of gravelly nature, retained on a 10-mesh sieve, i. e., more than 1.85 mm. diameter.

**Physical properties, coarse material.**

The coarse material, if any, of the aggregate, shall consist of hard, siliceous material, free from feldspar, mica, schist, hardpan, or other soft, friable material, in excess of 5 per cent.

**Mechanical analysis of material passing 10-mesh sieve.**

The material which will pass a 10-mesh sieve, when subjected to mechanical analysis, shall meet the following requirements:

| | Per cent. |
|---|---|
| Clay | _____ to _____ |
| Silt | _____ to _____ |
| Total sand | _____ to _____ |
| Sand retained on 60-mesh sieve | _____ to _____ |

**Methods of sampling and testing.**

The material shall be sampled in accordance with the method described on pages _____, paragraphs _____, of these specifications; and the mechanical analysis shall be made in accordance with the methods described or referred to on page _____ of these specifications, tests Nos. _____.

NOTE.—To cover the range of materials adaptable for road construction, it is recommended that roads of these types be divided into three classes, designated, Hard or Class A, Medium or Class B, and Soft or Class C, according to the mechanical analysis of the material which is to be specified for use. The limiting percentages of the constituents suggested for the three classes are as follows:

| | Hard or Class A. | Medium or Class B. | Soft or Class C. |
|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* |
| Clay | 9 to 15 | 15 to 25 | 10 to 25 |
| Silt | 5 to 15 | 10 to 20 | 10 to 20 |
| Total sand | 65 to 80 | 60 to 70 | 55 to 80 |
| Sand retained on 60-mesh sieve | 45 to 60 | 30 to 45 | 15 to 30 |

* The definitions here given are intended to apply to these terms only when used in connection with roads of these types.

### SPECIFICATION FOR SAND FOR SHEET ASPHALT.

General.

The sand shall be composed of sound, durable particles, free from a coating of clay or loam.

Grading.

When tested by means of laboratory sieves, it shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing 10-mesh sieve, not less than | ------ |
| Passing 10-mesh and retained on 40-mesh sieve | ------ to ------ |
| Passing 40-mesh and retained on 80-mesh sieve | ------ to ------ |
| Passing 80-mesh and retained on 200-mesh sieve | ------ to ------ |
| Passing 200-mesh sieve | ------ to ------ |

Methods of sampling and grading.

The sand shall be sampled for grading in accordance with the method described on page ------, paragraphs ------, of these specifications; and tests of grading shall be made in accordance with the method described or referred to on page ------ of these specifications, test No. ------.

NOTE.—It is recommended that volumetric analyses be reported by the laboratory to facilitate field control.

### SPECIFICATION FOR SAND FOR FINE AGGREGATE FOR PORTLAND-CEMENT CONCRETE BASE.

General.

The sand shall consist of clean, hard, durable, uncoated particles, preferably siliceous, free from lumps of clay and all organic matter.

Grading.

It shall be well graded from coarse to fine and, when tested by means of laboratory screens and sieves, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing 1/4-inch screen | 100 |
| Passing 20-mesh and retained on 50-mesh sieve | ------ to ------ |
| *Passing 50-mesh sieve, not more than | ------ |

Not more than ------ per cent by weight shall be removed by the elutriation test.

Mortar strength test.

When the sand is mixed with Portland cement in the proportion of 1 part of cement to 3 parts of sand, by weight, according to standard methods of making 1:3 mortar briquets, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least ------† per cent of that developed in the same time by mortar of the same proportions and consistency, made of the same cement and Ottawa sand.

Preliminary acceptance samples shall be subjected to both 7 and 28-day tests, and acceptance based thereupon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

---

* It is recommended that the amount passing the 50-mesh sieve be limited to 30 per cent, or less, if practicable.

† It is recommended that the minimum strength ratio for this purpose be 70 per cent, or greater, if possible under existing conditions; and that where sands giving a 70 per cent strength ratio are not available the proportion of cement be increased so as to give that percentage.

**Methods of sampling and grading.**

The sand shall be sampled in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading shall be determined in accordance with the methods described or referred to on page _____ of these specifications, tests Nos. _____.

NOTE.—It is recommended that volumetric analyses be reported by the laboratory to facilitate field control.

## SPECIFICATION FOR SAND FOR FINE AGGREGATE FOR PORTLAND-CEMENT CONCRETE WEARING SURFACE.

**General.**

The sand shall consist of clean, hard, durable, uncoated particles, preferably siliceous, free from lumps of clay and all organic matter.

**Grading.**

It shall be well graded from coarse to fine, and when tested by means of laboratory screens and sieves shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing ¼-inch screen | 100 |
| Passing 20-mesh and retained on 50-mesh sieve | _____ to _____ |
| *Total passing 50-mesh sieve—not more than | _____ |
| †Passing 100-mesh sieve—not more than | _____ |

Not more than _____ per cent by weight shall be removed by the elutriation test.

**Mortar strength test.**

When the sand is mixed with Portland cement in the proportion of 1 part of cement to 3 parts of sand, by weight, according to standard methods of making 1:3 mortar briquets, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least _____ ‡ per cent of that developed in the same time by mortar of the same proportions and consistency, made of the same cement and Ottawa sand.

Preliminary acceptance samples shall be subjected to both 7 and 28 day tests, and acceptance based thereupon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

**Methods of sampling and grading.**

The sand shall be sampled in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading shall be determined in accordance with the methods described or referred to on page _____ of these specifications, tests Nos. _____.

NOTE.—It is recommended that volumetric analyses be reported by the laboratory to facilitate field control.

## SPECIFICATION FOR GROUTING SAND.

**General.**

The sand shall consist of clean, hard, durable, uncoated particles, preferably siliceous, free from lumps of clay and all organic matter.

* It is recommended that 25 per cent be specified as the amount permitted to pass a 50-mesh sieve, and in localities where practicable that a smaller figure be used.

† It is recommended that 5 per cent be specified as the quantity permitted to pass.

‡ It is recommended that the strength ratio be 100 per cent for this purpose.

Grading.

It shall be well graded from coarse to fine and, when tested by means of laboratory screens, shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____* mesh sieve_____not less than | _____† |
| Passing 100-mesh sieve_____not more than | _____ |

Not more than _____ per cent by weight shall be removed by the elutriation test.

Mortar strength test.

When the sand is mixed with Portland cement in the proportions of 1 part of cement to 3 parts of sand by weight, according to standard methods of making 1:3 mortar briquets, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least _____‡ per cent of that developed in the same time by mortar of the same proportions and consistency, made of the same cement and Ottawa sand.

Preliminary acceptance samples shall be subjected to both 7 and 28 day tests, and acceptance based thereupon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

Methods of sampling and grading.

The sand shall be sampled in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading shall be determined in accordance with the methods described, or referred to, on page _____ of these specifications, tests Nos. _____.

---

NOTE.—It is recommended that volumetric analyses be reported by the laboratory to facilitate field control.

### SPECIFICATION FOR SAND FOR CUSHION.

Grading.

The sand shall pass a _____ inch laboratory screen, and not less than _____ per cent shall pass a 20-mesh sieve. The material removed by the elutriation test, consisting chiefly of clay and loam, shall not exceed _____ per cent by weight.

Methods of sampling and testing.

The sand shall be sampled in accordance with the method described on page _____, paragraphs _____, of these specifications; and the grading shall be determined in accordance with the methods described, or referred to, on pages _____ of these specifications, tests Nos. _____.

---

NOTE.—It is recommended that volumetric analyses be reported by the laboratory to facilitate field control.

### SPECIFICATION FOR MINERAL FILLER.

General.

The mineral filler shall consist of _____(insert types allowable)_____ It shall be free from foreign or other objectionable material and when tested by means of laboratory sieves shall meet the following requirements:

| | Per cent. |
|---|---|
| Passing _____-mesh sieve_____ | 100 |
| Passing _____-mesh sieve_____not less than | _____ |

---

* It is recommended that a 10-mesh sieve be specified.

† Ninety-five per cent is recommended for this purpose.

‡ It is recommended that 65 per cent be the minimum allowable strength ratio, and that in localities where practicable a higher strength ratio be specified.

**Methods of sampling and grading.**

The mineral filler shall be sampled for quality and grading in accordance with the method described on page _____, paragraph _____, of these specifications; and the grading shall be determined in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

## SPECIFICATION FOR ROAD OILS FOR COLD APPLICATION.

**General.**

The road oil shall be homogeneous and free from water.

**Physical and chemical properties.**

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), _____ to _____.
2. Flash point, not less than _____° C. (_____ F.).
   [*or* _____° C, (_____° F.) to _____° C. (_____° F.)*]
3. Specific viscosity at _____° C.† (_____° F.), _____ to _____.
4. Loss at 163° C. (325° F.), 5 hours, not more than _____%.
   (*or* _____ to _____ per cent.*)
   ‡(*a*) Float test of residue at 50° C. (122° F.), ____ to _____ sec.
5. Total bitumen (soluble in carbon disulphide) not less than _____ per cent.
6. Per cent of total bitumen insoluble in 86° B. naphtha, _____ to _____.

**Methods of testing.**

Tests of the physical and chemical properties of the road oil shall be made in accordance with the methods described or referred to on page _____ of these specifications, tests Nos. _____.

---

NOTES.—(1) In some instances it may be considered desirable to include a requirement for loss at 105° C. (221° F.), in which case the wording should be: Loss at 105° C. (221° F.), 5 hours, not less than _____ per cent.

(2) In some instances it may be considered desirable to include a requirement for the percentage of residue of _____ penetration, in which case the wording should be: Percentage of residue of _____ penetration, _____ to _____.

(3) In certain cases the inclusion of all the tests listed or noted may not be desirable, but it is necessary to use certain combinations of the tests in order to secure a material suitable for a specified purpose.

## SPECIFICATION FOR ROAD OILS FOR HOT APPLICATION.

**General.**

The road oil shall be homogeneous, free from water, and shall not foam when heated to _____° C. (_____° F.).

**Physical and chemical properties.**

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), _____ to _____.

---

* In cases where the presence of a volatile or light flux is desired the second form of the flash-point requirement and of the loss at 163° C. requirement should be used; in all other cases the first form of requirement is applicable.

† It is recommended that the viscosity determination be made at 25° C. (77° F.) or 40° C. (104° F.), according to the nature of the product desired.

‡ In case the oil is to be used as a dust layer only, this requirement is to be omitted.

2. Flash point, not less than _____° C. (_____° F.).
   [*or* _____° C. (_____° F.) to _____° C. _____° F.).*]
3. Specific viscosity at 100° C. (212°F.) _____ to _____
4. Float test at _____° C.† (_____° F.), _____ to _____ sec.
5. Loss at 163° C. (325° F.), 5 hours, not more than _____ per cent.
   (*or* _____ to _____ per cent.*)
   (*a*) Float test of residue 50° C. (122° F.), _____ to _____ sec.
   [*or* penetration of residue at 25° C. (77° F.), 100 g., 5 sec., _____ to _____.]
6. Total bitumen (soluble in carbon disulphide) not less than _____ per cent.
7. Per cent of total bitumen insoluble in 86° B. naphtha, _____ to _____.

**Methods of testing.**

Tests of the physical and chemical properties of the road oil shall be made in accordance with the methods described or referred to on page _____ of these specifications, tests Nos. _____.

---

NOTES.—(1) In some instances it may be considered desirable to include a requirement for the percentage of residue of _____ penetration, in which case the wording should be: Percentage of residue of _____ penetration, _____ to _____ per cent.

(2) In certain cases the inclusion of all the tests listed or noted may not be desirable, but it is necessary to use certain combinations of the tests in order to secure a material suitable for a specified purpose.

## SPECIFICATION FOR ASPHALT CEMENTS FOR USE IN BITUMINOUS MACADAM, BITUMINOUS CONCRETE AND SHEET ASPHALT, OR AS SEAL COAT OR POURED JOINT FILLER.

**General.**

The asphalt cement shall be homogeneous, free from water, and shall not foam when heated to _____°C. (_____°F.).

It shall meet the following requirements:

**Physical and chemical properties.**

1. Specific gravity 25°/25°C. (77°/77°F.), _____ to _____.
2. Flash point, not less than _____°C. (_____°F.).
3. Melting point, _____°C. (_____°F.) to _____°C. (_____°F.).
   (*or* ductility at _____° C. (_____° F.), not less than _____ cm. (or _____ to _____cm.)
4. Penetration at 25° C.‡ (77° F.), 100 g., 5 sec., _____ to _____.

---

* In cases where the presence of a volatile or light flux is desired, the second form of the flash-point requirement and of the loss at 163° C. requirement should be used; in all other cases the first form of requirement is applicable.

† It is recommended that the float test be made at 32° C. (90° F.) or 50° C.) (122° F.), according to the nature of the product desired.

‡ In some instances it may be desirable to insert a requirement for penetration at the temperatures of 0°C. (32°F.) and 46.1°C. (115°F.) in which cases the clauses would read as follows: Penetration at 0°C. (32°F.), 200 g., 60 sec., _____ to _____, or not less than _____. Penetration at 46.1°C. (115°F.), 50 g., 5 sec., _____ to _____, [*or* not more than _____].

5. Loss at 163° C. (325° F.), 5 hours, not more than _____ per cent.
   (*a*) Penetration of residue at 25°C. (77°F.), 100 g., 5 sec., not less than _____.
6. Total bitumen (soluble in carbon disulphide) not less than _____ per cent.
   (*a*) Organic matter insoluble, not more than _____ per cent.
   (*b*) Inorganic matter insoluble, not more than _____ per cent.
   (*or* _____ to _____ per cent).

**Method of testing.** Tests of the physical and chemical properties of the asphalt cement shall be made in accordance with the methods described, or referred to on page _____ of these specifications, tests Nos. _____.

---

NOTES.—(1) In some instances it may be considered desirable to include an 86° B. naphtha solubility clause, in which case the wording should be: Per cent of total bitumen insoluble in 86° B. naphtha, _____ to _____ per cent.

(2) In some instances it may be considered desirable to include a fixed carbon requirement, in which case the wording should be: Fixed carbon, _____ to _____ per cent.

(3) In certain cases the inclusion of all the tests listed or noted may not be desirable, but it is necessary to use certain combinations of the tests in order to secure a material suitable for a specified purpose.

## SPECIFICATION FOR TARS FOR COLD APPLICATION.

**General.** The tar shall be homogeneous.

**Physical and chemical properties.** It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), _____ to _____.
2. Specific viscosity at ____° C.* (____° F.), _____ to _____.
3. Total distillate by weight:

| | Per cent. |
|---|---|
| To 170° C. (338° F.), not more than | _____ |
| To 235° C. (455° F.), not more than | _____ |
| To 270° C. (518° F.), not more than | _____ |
| To 300° C. (572° F.), not more than | _____ |

   (*a*) Melting point of residue _____° C. (_____° F.), to _____° C°. (_____° F.).

4. Total bitumen (soluble in carbon disulphide, _____ to _____ per cent.

**Methods of testing.** Tests of the physical and chemical properties of the tar shall be made in accordance with the methods described, or referred to, on page _____ of these specifications, tests Nos. _____.

---

NOTES.—(1) In some instances it may be desirable to insert a specific gravity of distillate requirement after the melting point requirement, in which case the wording should be: (*b*) Specific gravity of total distillate 25°/25° C. (77°/77° F.), _____ to _____.

(2) In some instances it may be considered desirable to insert a requirement for solubility in dimethyl sulphate of one or more fractions of the distillate. In such cases insert as follows: Solubility in dimethyl sulphate of distillate from _____° C. (_____° F.) to _____° C. (_____° F.), _____ to _____ per cent.

---

* It is recommended that the viscosity determination be made at 25° C. (77° F.) or 40° C. (104° F.), according to the nature of the product desired.

## SPECIFICATION FOR REFINED TARS FOR USE IN BITUMINOUS MACADAM AND BITUMINOUS CONCRETE, OR AS SEAL COAT OR FOR HOT APPLICATION.

**General.**

The refined tar shall be homogeneous and free from water.

**Physical and chemical properties.**

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), _____ to _____.
2. Float test at _____° C.* (_____° F.), _____ to _____ sec.
3. Total distillate by weight:

| | Per cent. |
|---|---|
| To 170° C. (338° F.), not more than | _____ |
| To 235° C. (455° F.), not more than | _____ |
| To 270° C. (518° F.), not more than | _____ |
| To 300° C. (572° F.), not more than | _____ |

(*a*) Melting point of residue _____° C. (_____° F.), to _____° C. (_____° F.).

4. Total bitumen (soluble in carbon disulphide), _____ to _____ per cent.

**Methods of testing.**

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the methods described, or referred to, on page _____ of these specifications, tests Nos. _____.

---

NOTES.—(1) In some instances it may be desirable to insert a specific gravity of distillate requirement after the melting point requirement, in which case the wording should be: (*b*) Specific gravity of total distillate, 25°/25° C.) (77°/77° F.), _____ to _____.

(2) In some instances it may be considered desirable to insert a requirement for solubility in dimethyl sulphate of one or more fractions of the distillate. In such cases insert as follows: Solubility in dimethyl sulphate of distillate, from _____° C. (_____° F.) to _____° C. (_____° F.), _____ to _____ per cent.

(3) In some instances it may be desirable to specify the specific viscosity of the material at the temperature applied. In such cases insert as follows: Specific viscosity, _____° C. (_____° F.), _____ to _____.

## SPECIFICATION FOR REFINED TAR FOR USE AS POURED JOINT FILLER.

**General.**

The refined tar shall be homogeneous and free from water.

It shall meet the following requirements:

**Physical and chemical properties.**

1. Specific gravity, 25°/25° C. (77°/77° F.), _____ to _____.
2. Melting point, ____° C. (____° F.) to ____° C. (____° F.).
3. Total bitumen (soluble in carbon disulphide), _____ to _____ per cent.

**Methods of testing.**

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the methods described or referred to on page _____ of these specifications, tests Nos. _____.

## SPECIFICATION FOR PORTLAND CEMENT.†

**Definition.**

(1) Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination except water and calcined or uncalcined gypsum.

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* It is recommended that the float test be made at 32° C. (89.6° F.) or 50° C. (122° F.), according to the nature of the product desired.

† Conforming with the report of a joint conference representing the United States Government, American Society of Civil Engineers, and the American Society for Testing Materials, published in Bureau of Standards Circular No. 33, 3d edition, and in the 1913 Standards of the American Society for Testing Materials, p. 429, etc., Serial Designation C9–17.

## I. Chemical Properties.

**Chemical limits.**

(2) The following limits shall not be exceeded:

| | Per cent. |
|---|---|
| Loss on ignition | 4.00 |
| Insoluble residue | .85 |
| Sulphuric anhydride ($SO_3$) | 2.00 |
| Magnesia (MgO) | 5.00 |

## II. Physical Properties.

**Specific gravity.**

(3) The specific gravity of cement shall be not less than 3.10. Should the test of cement as received fall below this requirement, a second test may be made upon an ignited sample. The specific-gravity test will not be made unless specifically ordered.

**Fineness.**

(4) The residue on a standard 200-mesh sieve shall not exceed 22 per cent by weight.*

**Soundness.**

(5) A pat of neat cement shall remain firm and hard, and show no signs of distortion, cracking, checking, or disintegration in the steam test for soundness.

**Time of setting.**

(6) The cement shall not develop initial set in less than 45 minutes when the Vicat needle is used, or 60 minutes when the Gillmore needle is used. Final set shall be attained within 10 hours.

**Tensile strength.**

(7) The average tensile strength in pounds per square inch of not less than three standard mortar briquets composed of 1 part cement and 3 parts standard sand, by weight, shall be equal to or higher than the following:

| Age at test | Storage of briquets. | Tensile strength per square inch. |
|---|---|---|
| *Days.* | | *Pounds.* |
| 7 | 1 day in moist air, 6 days in water | 200 |
| 28 | 1 day in moist air, 27 days in water | 300 |

(8) The average tensile strength of standard mortar at 28 days shall be higher than the strength at 7 days.

## III. Packages, Marking, and Storage.

**Packages and marking.**

(9) The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon, unless shipped in bulk. A bag shall contain 94 pounds net. A barrel shall contain 376 pounds net.

**Storage.**

(10) The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness.

* The United States Government specification requires that on and after July 1, 1918, the residue on the 200-mesh sieve shall not exceed 20 per cent by weight.

### IV. Inspection.

**Inspection.**

(11) Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least 10 days from the time of sampling shall be allowed for the completion of the 7-day test; and at least 31 days shall be allowed for the completion of the 28-day test. The 28-day test shall be waived only when specifically ordered.*

### V. Rejection.

**Rejection.**

(12) The cement may be rejected if it fails to meet any of the requirements of these specifications.

(13) Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest after drying at 100°C. (212° F.) for one hour it meets this requirement.

(14) Cement failing to meet the test for soundness in steam may be accepted if it passes a retest using a new sample at any time within 28 days thereafter.

(15) Packages varying more than 5 per cent from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

**Method of sampling.**

The cement shall be sampled in accordance with the method described on page _____, paragraphs _____, of these specifications.

**Methods of testing.**

The cement shall be tested in accordance with the methods described, or referred to, on page _____ of these specifications, tests Nos. _____.

### SPECIFICATION FOR PORTLAND-CEMENT CONCRETE FOR WEARING SURFACE. (SUGGESTED CLAUSES FOR COMPOSITION AND CONSISTENCY.)

**Composition.**

The concrete shall be composed of 1 part of Portland cement and _____ parts of fine and coarse aggregate, measured separately and accurately by volume, and combined in such proportions as may be directed by the engineer, so as to give concrete of the greatest density and strength. The concrete shall be mixed in the approximate proportions of 1 part cement, _____ parts fine aggregate, and _____ parts coarse aggregate. In no case shall the parts of fine aggregate be less than _____† per cent nor more than _____‡ per cent of the total parts by volume of fine and coarse aggregate.

**Consistency.**

The consistency of concrete should be such that when deposited it will settle in a flat mass, but will not flow on the subgrade. No tamping should be required, and no separation of the mortar from the coarse aggregate should occur in handling the concrete or in finishing the surface.

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* The conference recommends that in the application of this clause to working conditions the cement should not be held ordinarily pending the results of the 28-day test, but these tests nevertheless should be made invariably.

† The figure 30 is suggested.

‡ The figure 40 is suggested.

### SPECIFICATION FOR STEEL REINFORCING RODS.

**General.** Rods shall be (insert form selected)* and (insert method of manufacture desired)† and shall conform to the following chemical and physical requirements. Twisted bars shall be twisted with one complete twist in a length not over 12 times the thickness of the bar.

**Chemical properties.** Rods shall meet the following chemical requirements:‡

Phosphorus—

Bessemer, not more than ____§ per cent.
Open-hearth, not more than ____§ per cent.

**Physical properties.** Rods shall meet the following requirements for physical properties:

Tension tests—

Tensile strength, not less than ____§ pounds per square inch.
Yield point, not less than ____§ pounds per square inch.
Elongation in 8 inches, not less than ____§ per cent.

Cold bend test without cracking—

Thickness or diameter under ¾ inch, ____§°.
Thickness or diameter ¾ inch or more ____§°.

**Modifications in elongation.** For plain and deformed bars over three-quarters inch in thickness or diameter, a deduction of 1 from the percentages of elongation specified in the foregoing table shall be made for each increase of one-eighth inch in the thickness or diameter above three-fourths inch.

For plain and deformed bars under seven-sixteenths inch in thickness or diameter, a deduction of 1 from the percentages of elongation specified in the foregoing table shall be made for each decrease of one-sixteenth inch in thickness or diameter below seven-sixteenths inch.

**Weight.** The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

**Storage.** Steel rods shall be so stored as to prevent the formation of rust scales and when used on the work they shall be free from dust, dirt, loose rust, paint, oil, or grease.

**Methods of sampling and testing.** Rods shall be sampled in accordance with the methods described on page ____, paragraphs ____, of these specifications, and tested in accordance with the methods described or referred to on pages ____ of these specifications, tests Nos. ____.

### SPECIFICATION FOR VITRIFIED PAVING BRICK.

**General.** All brick shall be of a size commercially known as "vitrified block." They shall be thoroughly annealed, tough and durable, regular in size and shape and evenly burned. When broken the bricks shall show a dense, stonelike body, free from lime, air

* Plain, deformed, hot or cold twisted, as may be desired.

† Rolled from new billets made by Bessemer or open-hearth process or rolled from standard section tee rails, as may be specified.

‡ To be applied only to rods rolled from billets.

§ The values given in American Society for Testing Materials Standards, 1916, serial designation A15–14, for the particular kind of material desired, are recommended for insertion in this table.

pockets, cracks, or marked laminations. Kiln marks shall not exceed _____ of an inch, and the wearing surface shall show but slight kiln marks.

Rattler test.

Representative samples of the brick shall meet the following requirements when subjected to the rattler test:

Average loss by abrasion on one or more tests, not more than _____ per cent.

Maximum difference in per cent loss by abrasion when more than one representative sample is tested, not more than _____per cent.

A maximum of three tests will be used as a basis for rejection.

Dimensions.

The bricks shall meet the following requirements:

Length _____ to _____ inches.

Width, _____ to _____ inches.

Depth, _____ to _____ inches.

Variations among bricks from a single plant shall not exceed the following limits:

Variation in length, _____ inch.

Variation in width, _____ inch.

Variation in depth, _____ inch.

If the edges of the bricks are rounded, the radius shall not exceed _____ of an inch.

Only bricks with lugs on one side, raised not less than _____ of an inch, nor more than _____ of an inch, shall be used.

Visual inspection.

The bricks shall be subjected to inspection subsequent to delivery at the place of use, prior to and during laying, in order to cull out and reject upon variations from the general and dimensions clauses and upon the following grounds:

All bricks which are broken through, or chipped in such manner that neither wearing surface remains substantially intact, or in such manner that the lower or bearing surface is reduced in area by more than one-fifth.

All bricks which are cracked to a depth greater than _____-inch on any surface, or which are cracked on the wearing surface.

All bricks which are so off-size or so misshaped, bent, twisted, or kiln-marked that they will not form a proper surface or align properly with other bricks.

All bricks which are obviously too soft and too poorly vitrified to endure street wear.

Methods of sampling and testing.

Bricks shall be sampled in accordance with the method described on page _____ of these specifications, and tested in accordance with the method described or referred to on page _____ of these specifications, test No. _____.

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NOTE.—The committee does not recommend an absorption test for general use in specifications. If special conditions make such a test necessary, it may be specified.

## RECOMMENDED STANDARD METHODS OF TESTING MATERIALS.

### TESTS OF PHYSICAL PROPERTIES OF STONE, SLAG, GRAVEL, AND SAND.

(1) ABRASION TEST (PER CENT OF WEAR, OR FRENCH COEFFICIENT OF WEAR), STONE, STONE BLOCK, AND SLAG: United States Department of Agriculture Bulletin 347, page 5.

NOTES.—(*a*) Attention is directed to the fact that tests of rock and slag for abrasion by the use of the Deval machine are not entirely satisfactory. The formation of a dust cushion in the cylinder partially prevents the abrasion of the stone. Sufficient data are not at hand to show the amount of wear when this dust cushion is removed after intervals of time.

(*b*) It is hoped that laboratories will take up this test with the idea of developing a coefficient of wear more nearly representative of the actual resistance of the stone.

(*c*) It is desired to call attention to the fact that two methods of preparing the stone or slag are in use—viz, hand breaking and machine breaking, and furthermore to recommend that arrangements be made between States for conducting check tests for abrasion on portions of the same sample.

(*d*) In testing light stone and light slag, it is recommended that some standard volume be substituted for the standard weight of 5,000 grams.

(*e*) In the case of stone block it is recommended that the laboratories cooperate to devise new methods of testing stone block to determine their suitability for pavements.

(2) ABRASION TEST, SUGGESTED FOR GRAVEL:

The aggregate is screened first through screens having circular openings 2 inches, 1 inch, and ½ inch in diameter. The sizes used for this test are divided equally between those passing the 2-inch and retained on the 1-inch screen, and those passing the 1-inch and retained on the ½-inch screen. The material of these sizes is washed and dried. The following weights of the dried stone are then taken: 2,500 grams of the size passing the 2-inch and retained on the 1-inch screen, and 2,500 grams of the size passing the 1-inch and retained on the ½-inch screen. This material is placed in the cast-iron cylinder of the Deval machine as specified for the standard abrasion test on stone. Briefly described, this machine consists of a frame and two or more cylinders mounted at an angle of 30° with the axis of rotation. The cylinders are of the following size: 20 cm. diameter by 34 cm. deep, inside dimensions. Six cast-iron spheres 1.875 inches in diameter and weighing approximately 0.95 pound (0.45 kg.) each, are placed in the cylinder as an abrasive charge. The iron composing these spheres, which are the same as those used in the standard paving brick rattler test, has the following limits of composition:

Combined carbon, not under 2.50 per cent.
Graphitic carbon, not over 0.25 per cent.
Silicon, not over 1.00 per cent.
Manganese, not over 0.50 per cent.
Phosphorus, not over 0.25 per cent.
Sulphur, not over 0.08 per cent.

After the cast-iron spheres have been placed in the cylinder the lid is bolted on and the cylinder mounted in the frame of the Deval machine. The duration of the test and the rate of rotation are the same as specified for the standard test for stone, namely, 10,000 revolutions at a rate of 30 to 33 revolutions per minute. At the completion of the test the material is taken out and screened through a 16 mesh sieve. The material retained upon the sieve is washed and dried and the per cent loss by abrasion of the material passing the 16 mesh sieve calculated.

When the material has a specific gravity below 2.20 a total weight of 4,000 grams instead of 5,000 grams shall be used in the abrasion test.

(3) TOUGHNESS TEST, STONE: United States Department of Agriculture Bulletin 347, page 15.

(4) HARDNESS TEST,[1] STONE AND STONE BLOCK: United States Department of Agriculture Bulletin 347, page 10.

(5) SPECIFIC GRAVITY AND ABSORPTION TESTS, STONE:

The apparent specific gravity is obtained by weighing the water displaced by a sample of the material weighing approximately 1,000 grams, broken into pieces about 1¼ inches in diameter. (The vessel used is shown in figure 1.)

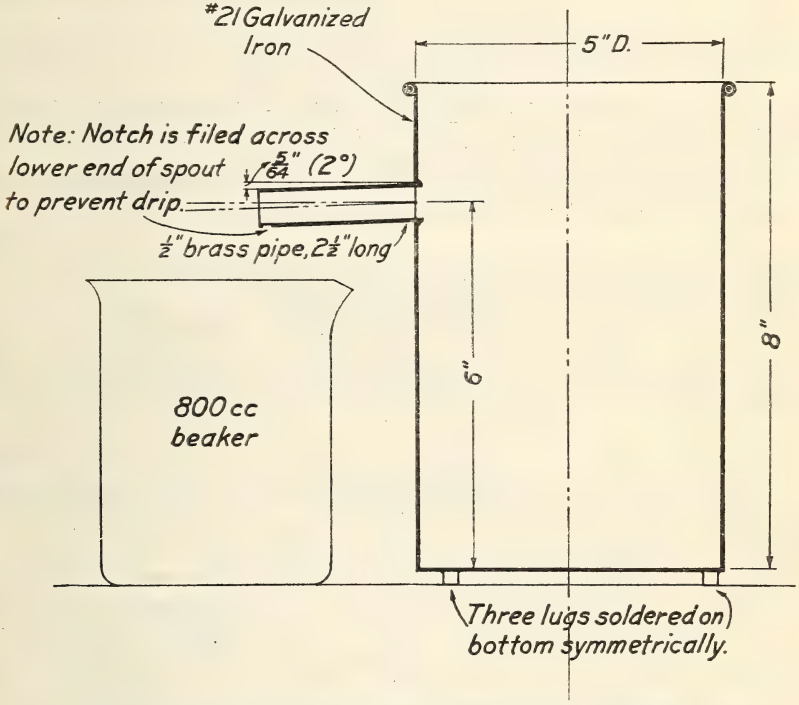


FIG. 1.—Vessel used in making specific-gravity and absorption tests.

It consists of a galvanized-iron cylinder closed at one end, and measuring 5 inches in diameter by 8 inches high. A brass spout ½ inch in diameter is soldered into the side of the cylinder, 6 inches from the bottom. The spout is inclined at an angle of 2° with the horizontal and is 2½ inches long. A notch is filed across its lower end, as shown, to stop the drip from the displaced water. In determining the specific gravity, the dried and cooled sample is weighed to the nearest 0.5 gram and immersed in water for 24 hours. The pieces are then individually surface-dried with a towel, the sample reweighed, and immediately placed in the cylinder, which has been previously filled to overflowing with water at room temperature.

The weight of water displaced by the sample is used to calculate its apparent specific gravity.

[1] It is recommended that the laboratories cooperate with the view of devising an improved method for the determination of the hardness of rock, especially in regard to the character of the abrasive used.

The difference between the original weight of the sample and its weight after 24 hours immersion is used to determine the absorption.

(6) WEIGHT PER CUBIC FOOT TEST, SLAG:

The dried slag shall be shaken to refusal in a cubic-foot measure or other suitable container, and its weight determined.

(7) MORTAR-STRENGTH TEST, SCREENINGS AND SAND: A. S. T. M. Standard test C9–17.

## SIZE, GRADING, OR MECHANICAL ANALYSIS OF STONE, SLAG, GRAVEL, SAND.

(8) TEST OF SIZE OR GRADING OF COARSE AGGREGATE, STONE, SLAG, AND GRAVEL:

A sample of the material weighing not less than fifty (50) times the weight of the largest size stone present is to be used. After drying at not over 110°C. (230°F.) to constant weight the sample is passed through such of the following size screens, having circular openings, as are required or called for by the specifications, screens to be used in the order named: 3½-inch, 3-inch, 2½-inch, 2-inch, 1½-inch, 1-inch, ¾-inch, ½-inch, and ¼-inch.

The percentage by weight, retained on each screen, is determined and the mechanical analysis is recorded in the following manner:

| | Per cent. |
|---|---|
| Passing 3½-inch screen and retained on 3-inch screen | --- |
| Passing 3-inch screen and retained on 2½-inch screen | --- |
| Passing 2½-inch screen and retained on 2-inch screen | --- |
| | --- |
| Passing ½-inch screen and retained on ¼-inch screen | --- |
| Passing ¼-inch screen | --- |
| | 100 |

(9) WASHING TEST AND MECHANICAL ANALYSIS, ROAD GRAVEL:

A sample of the material weighing not less than 50 times the weight of the largest size stone present is to be used. After thoroughly drying at 100° C. (212° F.) in a hot-air bath, the sample is cooled, weighed, and placed in a shallow pan, covered with water, and thoroughly agitated by means of a trowel for 15 seconds. After 15 seconds sedimentation the water is poured off through a 200-mesh sieve, and the operation of agitation, sedimentation, and decantation repeated until the wash water is approximately clear after 15 seconds. The washed material, together with any residue retained on the 200-mesh sieve, is then dried to constant weight, cooled and weighed and passed through such of the following size screens and sieves as are called for in the specification, using them in the order named.

*Screens* (circular openings): 3-inch, 2½-inch, 2-inch, 1½-inch, 1-inch, ¾-inch, ½-inch, and ¼-inch.

*Sieves* A. S. T. M. standard method D7–16 (square mesh): 10, 20, 30, 40, 50, 60, 80, 100, and 200 meshes per linear inch.

The percentage by weight retained on each screen or sieve and based on the weight of the original sample is calculated, using for the determination of the percentage of material passing the 200-mesh sieve the sum of the weights of material passing this sieve by analysis and by washing.

(10) ELUTRIATION TEST, SAND OR FINE AGGREGATE:

The entire sample is moistened and thoroughly mixed, and a sample weighing approximately 105[1] grams is obtained for elutriation and grading by quartering or by selecting small portions from various parts of a flat pile. The sample is then dried at not over 110° C. (230° F.). This dried sample is accurately weighted and placed in a 500-cc.[1] beaker, and about 350 cc.[1] of

water is added and agitated in such manner that no whirling results. After settling for 20 seconds the water is poured off through a 200-mesh sieve, and the operation of agitation, sedimentation, and decantation repeated until the wash water is approximately clear. Particles caught on the 200-mesh sieve are then washed back into the washed sample remaining in the beaker. The entire washed sample is dried to constant weight and accurately weighed, and the

$$\text{Per cent by elutriation} = \frac{\text{Original weight} - \text{final weight}}{\text{Original weight}}$$

(11) Mechanical Analysis, Sand or Fine Aggregate:

All of the dried sample remaining after the elutriation test, if such is required, is passed successively through the desired screens and sieves, beginning with either the largest or smallest as may be convenient. Where an elutriation test is not required, a dried sample of the original material is used.

The percentage by weight, of the unwashed sample retained on each screen is determined, and the mechanical analysis is recorded according to one or both of the following methods. A screen with ¼-inch circular openings is used, together with square-mesh sieves as specified in A. S. T. M. standard method D7–16.

| | Per cent. |
|---|---|
| Total retained on ¼-inch screen | ____ |
| Passing ¼-inch screen and retained on 10-mesh sieve | ____ |
| Passing 10-mesh sieve and retained on 20-mesh sieve | ____ |
| Passing 20-mesh sieve and retained on 30-mesh sieve | ____ |
| Passing 30-mesh sieve and retained on 40-mesh sieve | ____ |
| Passing 40-mesh sieve and retained on 50-mesh sieve | ____ |
| Passing 50-mesh sieve and retained on 80-mesh sieve | ____ |
| Passing 80-mesh sieve and retained on 100-mesh sieve | ____ |
| Passing 100-mesh sieve and retained on 200-mesh sieve | ____ |
| Passing 200-mesh sieve | ____ |
| Total | 100 |

| | Per cent. |
|---|---|
| Total passing ¼-inch screen | ____ |
| Total passing 10-mesh sieve | ____ |
| Total passing 20-mesh sieve | ____ |
| Total passing 30-mesh sieve | ____ |
| Total passing 40-mesh sieve | ____ |
| Total passing 50-mesh sieve | ____ |
| Total passing 80-mesh sieve | ____ |
| Total passing 100-mesh sieve | ____ |
| Total passing 200-mesh sieve | ____ |
| Passing 200-mesh sieve elutriation | ____ |

## MECHANICAL ANALYSIS AND TESTS OF PHYSICAL PROPERTIES OF SEMI-GRAVEL, TOP-SOIL, AND SAND-CLAY AGGREGATES.

### INTRODUCTION BY THE COMMITTEE.

The committee has been charged with consideration of that large range of natural soils and aggregates which lie below the usual classification of gravel, and which in the past 10 years have commended themselves to low-cost road

[1] If the sand is so coarse that a 100-gram sample is not sufficient, the size of the sample, the container, and the amount of water used may be proportionally increased.

surfacing in various sections of the country. The terms sand-clay roads, top-soil roads, and semi-gravel roads have come into road literature as designating various types of construction that utilize either natural surface soil, or subsurface deposits, or artificial mixtures wherein the chief ingredients are siliceous sands and natural clays. The abundant distribution of these two soil ingredients either separately in deposits or already mixed in many soils and substrata, has attracted attention and experiment to an extent which now justifies some attempt at classification and more definite statement of specifications and methods upon which satisfactory results may be predicated.

The better known and more expensive road surfacing materials have had the benefit of long study and detailed specification as a basis for control of contract work. But much of the large mileage of the types herein considered has been constructed by force account and with comparatively recent study of the proper bases and considerations out of which systematic specifications and methods could be formulated. The prospect of Federal-aid contracts in various States makes it very desirable that some such standardization should now be attempted as a guide to expenditures in those States where such types of construction either now prevail or where conditions indicate their desirability and efficiency in connection with possible Federal-aid projects.

The present state of knowledge regarding these materials is derived from the comparative study of the road history under traffic of such roads and the mechanical analyses of the constituent materials. The data secured indicate the necessity of classification and tests based upon a more complete separation of the ingredients than is usually given in a laboratory analysis. Special definitions of the terms "sand," "silt," and "clay" are required, also a theory of their mutual interaction after consolidation. It is believed that the adhesive clay, acting as a binder in dry weather and as a stopper to capillary openings by swelling in wet weather, must be supplemented by the interlocking strength of the sand aggregate both in dry and in wet weather to support the weight and the wear of the traffic, while the nonadhesive silt gives aid to density and water resistance. The proportions and sizes of the sand content are highly important for the strength and wearing element. The clay, owing to its expansion under wet conditions, should be present in minimum amount consistent with sufficient adhesion in dry weather, and the silt should form the inert filler for those voids not occupied by the clay.

The thorough intermixing of the ingredients is a vital factor and a process of consolidation which will pack the loose mass from the bottom upward is of much consequence.

A further conception of the action of this class of materials suggests that the fine aggregate passing a 10-mesh sieve may be regarded as a mortar capable of being used separately to form the road slab or of carrying any amount of gravel or coarse aggregate up to the point where a complete gravel road is reached with this mortar as its binder. Experience has shown that the addition of coarse material retained on a 10-mesh sieve and less than 2 inches in size, provided the coarse material is itself present in graded sizes, increases the durability of these soil mixtures. Further, the analysis of the fine material passing a 10-mesh sieve in the well-known Augusta (Ga.) gravel, which possesses excellent binding value, reveals a composition similar to some of the best top-soil roads in that State. There is reason to think that the binders in washed gravel roads might very well be compounded on the same basis as successful soil road mixtures.

The successful use of these road soil mixtures, whether obtained on the surface, as top soils, from substrata, or from artificial mixtures of clay and sand, depends primarily on the composition as to size, amount, quality, and

uniformity of mixing of the three usual ingredients and upon the adequate consolidation of the mass. From the practical standpoint the selection of the raw material should not be based on a too narrow analytic figure. The natural deposits are of variable composition. A number of samples from a selected area close to the work may not conform to a specific percentage, but it is usually possible to supplement deficiencies by adding relatively small quantities of sand or clay, as the case may be, and secure in the mixed roadbed a fairly uniform material whose analysis is satisfactory.

The final acceptance of a material of this class should preferably be based on samples taken at specified intervals on the freshly laid and intermixed roadbed and at such other points as the inspector may choose where the indications are that the mixture is not uniform and satisfactory.

In the light of the above brief statement the specifications, methods of test, methods of sampling, and form of reporting test results on these materials will be more readily understood.

(12) Examination Semi-Gravel, Top-Soil, and Sand-Clay:

Dry 500 grams of the material at a temperature below 350° F. (176.6° C.) to constant weight. Gently pulverize to break down soft clods or masses, but not to grind or break hard material. Pass through a 10-mesh sieve, weigh the coarse residue and record as "coarse material." Use the material passing the 10-mesh sieve as the starting point of a percentage analysis as follows:

Weigh out two samples of 50 grams of this material for duplicate analysis. Place each in a wide mouth bottle (5 to 6 cm. diameter and about 12 to 15 cm. high). Add about 5 c. c. of dilute ammonia water and about 200 c. c. of water. Close with a cork or glass stopper and shake thoroughly for 20 minutes. Allow the sample to settle eight minutes and decant carefully or siphon off the supernatant liquid to a depth of 8 cm. below the surface of the liquid. (The depth of the liquid in the bottle should be sufficient to leave about 4 cm. below the point of siphoning.) Fill the bottle again with water, shake for three minutes, allow settlement, and siphon off as before. Repeat the process until the supernatant liquid is clear. Be careful to wash the stopper and neck of the bottle free from coarse material before decanting. The washings drawn off may be collected and evaporated to dryness for direct recovery of the fine sediment classed as "clay." Ordinarily the sediment loss or clay is computed as difference.

Wash the contents of the bottle cleanly into a porcelain evaporating dish and carry to dryness on a water bath. The dried residue should be carefully scraped from the dish and passed through a nest of 20, 60, 100, and 200 mesh sieves. The residue retained on each sieve is weighed and recorded as sand of the respective sizes. Their sum constitutes the total "sand." The residue passing the 200-mesh sieve and caught in the pan is weighed and recorded as "silt." Duplicate samples should check within 1 per cent.

(*a*) The coarse material should be examined for hardness and with the magnifying glass to identify its character as quartz, hard iron compounds, feldspar, schistose material, or indurated clay. Hard quartz or iron gravels are valuable in themselves and as indicating the quality of the finer aggregate. Feldspar, mica, and clay nodules are worthless and indicate that the accompanying soil is poor for road building.

(*b*) The sands should be examined with the magnifying glass for identification as quartz and for the presence of mica scales or feldspar needles. If mica or feldspar is present in appreciable amounts the sample should be rejected.

(*c*) When the clay is recovered by evaporation it can be examined for tenacity by cementing together two glass plates, each 1 inch wide, set at right angles, with a layer of clay whose thickness is fixed by a fine bent wire laid between

the plates. The moist clay covers the wire on one plate, and the other plate is squeezed down tightly on the wire. After drying, the one plate being held firmly against cleats, wire slings are run symmetrically from the ends of the upper plate to one arm of a beam balance, and the tension necessary to separate the plates is given by shot or weights in the other pan of the balance. This test is tedious and is of service chiefly on low-grade samples which are of doubtful efficiency, but which represent the only available material for local construction.

(*d*) Approximate tests for tenacity of mixture can be made as follows:

Make cylinders from the material passing the 10-mesh sieve, 25 mm. by 25 mm. The material is worked into a stiff mud and molded under 132 kg. per sq. cm. pressure. Dry thoroughly at 100° C. (212° F.) and break by the small Page impact machine for testing cementing value, using a 1 kg. hammer and 1 cm. drop. Record the number of strokes as the relative measure of tenacity.

Mix 50 grams of the material passing the 10-mesh sieve with ——— grams of water and knead with the hands into a spherical ball. Measure the diameter. Let this ball drop from a height of ——— cm. on a flat slab. Measure and record the reduction in diameter and examine the surface for cracks.

Usually the plastic character and adhesiveness of a good road soil can be judged by the feeling of the mud made from this material, its adherence to the hands, and its stretch under light pulling.

## TESTS OF PHYSICAL AND CHEMICAL PROPERTIES OF BITUMINOUS MATERIALS.

(13) Specific Gravity: Standardized hydrometers or pycnometers. U. S. Department of Agriculture Bulletin 314, pp. 4 to 7.

(14) Flash Point (Open Cup): U. S. Department of Agriculture Bulletin 314, p. 17.

(15) Melting Point: A. S. T. M. tentative standard D36–16T; Proc. A. S. T. M. 1916, p. 549.

(16) Ductility: A. S. C. E. 1914 Proceedings, p. 3047.

(17) Penetration: A. S. T. M. standard test D5–16.

(18) Float Test: U. S. Department of Agriculture Bulletin 314, p. 9.

(19) Specific Viscosity (on First 50 c.c.): U. S. Department of Agriculture Bulletin 314, p. 7.

(20) Total Bitumen and Organic and Inorganic Matter Insoluble in Carbon Disulphide: U. S. Department of Agriculture Bulletin 314, p. 25.

(21) Bitumen Insoluble in Naphtha: U. S. Department of Agriculture Bulletin 314, p. 28.

(22) Volatilization Test (Loss at 163° C. or Other Temperature): U. S. Department of Agriculture Bulletin 314, p. 19, except that a 50-gram sample is used in a flat-bottom box 55 mm. diameter by 35 mm. deep (Gill style, 3-ounce deep pattern box).

(23) Distillation Test: A. S. T. M. standard test D20–16.

(24) Fixed Carbon: U. S. Department of Agriculture Bulletin 314, p. 30.

(25) Dimethyl Sulphate Test: U. S. Department of Agriculture Bulletin 314, p. 25.

(26) Percentage of Residue of ——— Penetration:

Fifty grams of the oil are placed in a 3-ounce deep, seamless tin box; the box is placed in a sand bath and heated over a Bunsen burner. A thermometer is suspended in the oil, the bulb not touching the bottom of the box. The temperature of the oil is kept at from 249° C. (480° F.) to 260° C. (500° F.), and the oil is stirred from time to time with the thermometer to prevent over-

heating in any part. Depending upon the nature of the oil, as usually indicated by its flash, consistency at 25° C. (77° F.), and specific gravity, the operator can with experience tell about what percentage it will be necessary to evaporate before cooling and taking a penetration of the residue. It is sometimes necessary to make several trials before the desired result is obtained. When the required penetration is reached the residue left from evaporation is weighed and its per cent of the original sample taken is computed.

## TESTS OF PORTLAND CEMENT, PORTLAND CEMENT CONCRETE, STEEL REINFORCING RODS, AND VITRIFIED PAVING BRICK.

(27) TESTS OF PORTLAND CEMENT:

(*a*) Chemical analysis, A. S. T. M. standard test C 9–17.
(*b*) Specific gravity, A. S. T. M. standard test C 9–17.
(*c*) Fineness, A. S. T. M. standard test C 9–17.
(*d*) Soundness, A. S. T. M. standard test C 9–17.
(*e*) Time of setting, A. S. T. M. standard test C 9–17.
(*f*) Tensile strength, A. S. T. M. standard test C 9–17.

(28) TESTS OF FIELD SAMPLES OF PORTLAND CEMENT CONCRETE:

*Form of specimen.*—The test specimen may be a cube, a prism, or a cylinder, but it is felt that a cylinder six (6) inches in diameter by twelve (12) inches high will give the most satisfactory results. Molds of all types can be successfully used, from the most permanent to those which can be used only in forming a single specimen.

*Molding specimens.*—The molding should be done as near the mixer as practicable, and the concrete should be conveyed to the molds with as little jarring or mixing as possible. The molds should be placed on a flat, nonabsorbent surface, and the concrete should be placed in layers of _____ inches, with slight puddling by means of a half-inch steel rod.

*Storing.*—Specimens should be permitted to remain in position where molded for a period of 24 hours. At the end of that period they may be stored on the completed concrete pavement, buried in the same covering material, and moistened at the same intervals, until ready for shipment to the laboratory; or, if not considered practicable to store on the completed concrete, they may be covered at the point of molding with the same covering material as used for the concrete pavement and moistened at the same intervals, until shipped to the laboratory.

*Shipment.*—Specimens must be suitably protected from injury during shipment.

*Testing.*—Specimens should be capped with mortar shortly after molding, or with plaster of Paris just before testing, so as to provide plane bearing surfaces. The plane surface is formed by placing the specimen on a flat, nonabsorbent surface and pressing a flat plate on the soft mortar or plaster cap. In testing, the specimens are mounted in the testing machine with spherical bearing block placed on top of the specimen, the capped specimen being placed in direct contact with the steel bearing surfaces.

(29) TESTS OF STEEL REINFORCING RODS: As given in the standard specifications for reinforcement bars, A. S. T. M. standard, 1916, serial designations A 15–14 and A 16–14.

(30) RATTLER TESTS, VITRIFIED PAVING BRICK: A. S. T. M. standard specification C 7–15.

NOTE.—All of the American Society for Testing Materials Methods, Tests, or Specifications above referred to will be found in the A. S. T. M. Standards, 1916, unless otherwise noted.

## RECOMMENDED STANDARD FORMS FOR REPORTING TEST RESULTS.[1]

(Name and location of laboratory:)

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REPORT ON SAMPLE OF ROCK OR SLAG.

Laboratory No. ----------

----------, 191__.
(Date reported.)

Name----------
Identification marks ----------
Submitted by---------- Title---------- Address----------
Sampled----------, 191__. Received----------, 191__
Sampled from----------
Quantity represented----------
Source of material----------
Location used or to be used----------
Examined for ----------

TEST RESULTS.

Specific gravity----------
Weight per cubic foot, in pounds----------
Water absorbed per cubic foot, ----------pounds ----------per cent
Per cent of wear---------- ----------
French coefficient of wear---------- ----------
Hardness---------- ----------
Toughness---------- ----------
Remarks:

Respectfully submitted.

----------
(Title)----------

[1] The arrangement of the test results on the report for gravel or sand, as reported by the conference, has been altered slightly so that the report might be made on a single sheet. In the case of petroleum and asphalt products and tars, the tests to be reported upon were definitely recommended by the conference, but no specific recommendation was made as to the order of arranging the various test results on the report form. The form, as presented, has been arranged in editing.

(Name and location of laboratory:)

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REPORT ON SAMPLE OF GRAVEL OR SAND.

Laboratory No. _____

_____, 191__.
(Date reported.)

Name_____

Identification marks _____

Submitted by_____ Title_____ Address_____

Sampled_____, 191__. Received_____, 191__

Sampled from_____

Quantity represented_____

Source of material_____

Location used or to be used_____

Examined for _____

TEST RESULTS.

| SAND. Mechanical analysis. | | GRAVEL. Mechanical analysis. | |
|---|---|---|---|
| Fraction. | Per cent. | Fraction. | Per cent. |
| Retained ½-inch screen | | Retained 3-inch screen | |
| Passing ½-inch retained 10 mesh | | Passing 3-inch retained 2½ inch | |
| Passing 10 mesh retained 20 mesh | | Passing 2½-inch retained 2 inch | |
| Passing 20 mesh retained 30 mesh | | Passing 2-inch retained 1½ inch | |
| Passing 30 mesh retained 40 mesh | | Passing 1½-inch retained 1 inch | |
| Passing 40 mesh retained 50 mesh | | Passing 1-inch retained ¾ inch | |
| Passing 50 mesh retained 60 mesh | | Passing ¾-inch retained ½ inch | |
| Passing 60 mesh retained 80 mesh | | Passing ½-inch retained ¼ inch | |
| Passing 80 mesh retained 100 mesh | | Passing ¼-inch screen | |
| Passing 100 mesh retained 200 mesh | | | |
| Passing 200 mesh | | | |
| Total | | Total | |
| Silt in sand | | Per cent of wear | |

| Tensile strength (cement-sand briquettes, 1:3). | Sample sand. | | | Standard Ottawa sand. | | |
|---|---|---|---|---|---|---|
| | 3-day. | 7-day. | 28-day. | 3-day. | 7-day. | 28-day. |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| Average | | | | | | |
| Ratio | | | | | | |

Remarks:

Respectfully submitted,

_____
(Title)_____

(Name and location of laboratory:)

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REPORT ON SAMPLE OF SEMI-GRAVEL, TOP SOIL, OR SAND CLAY.

Laboratory No. _____ _____, 191__
(Date reported.)

Name_____
Identification marks _____
Submitted by_____ Title_____ Address_____
Sampled_____, 191__ Received_____, 191__
Sampled from _____
Quantity represented _____
Source of material_____
Location used or to be used_____
Examined for _____

TEST RESULTS.

*Analysis of material passing 10-mesh sieve.*

| | Per cent. | Per cent. | Per cent. | Character. |
|---|---|---|---|---|
| Sand retained, 20 mesh | | | | |
| Passing 20, retained 60 mesh | | | | |
| Passing 60, retained 100 mesh | | | | |
| Passing 100, retained 200 mesh | | | | |
| Total sand | | | | |
| Silt | | | | |
| Clay | | | | |
| Total | | | | |
| Total sand retained on 60 mesh | | | | |

Coarse material, _____ per cent. Quality, _____.
Mica, _____.
Remarks:

Respectfully submitted,

_____
(Title)_____

(Name and location of laboratory:)

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REPORT ON SAMPLE OF PETROLEUM OR ASPHALT PRODUCTS.

(Classification name of material.)

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Laboratory No_____ _____, 191__
(Date reported.)

Trade name_____
Identification marks_____
Submitted by_____ Title_____ Address_____
Sampled_____, 191__ Received_____, 191__
Sampled from_____
Quantity represented_____
Manufactured by_____
Location used or to be used_____
Examined for_____

TEST RESULTS.

General characteristics_____
Specific gravity, 25° C./25° C._____
Flash point (° C.)_____
Specific viscosity, Engler at _____° C._____
Float test, _____° C., (seconds) _____; _____° C., (seconds) _____
Penetration, 25° C., 100 grams, 5 seconds _____
" 0° C., 200 " 60 " _____
" 46.1° C., 50 " 5 " _____
Melting point, (° C.)_____
Ductility, _____° C., _____ cm. _____° C., _____ cm.
Loss at 105° C., 5 hours_____
Loss at 163° C., 5 hours_____
Characteristics of residue_____
Consistency of residue { Pentration 25° C., 100 grams, 5 seconds _____
Float test, __° C., (seconds) ___; ___° C., (seconds)____
Total bitumen (soluble in $CS_2$)_____
Organic matter insoluble_____
Inorganic matter insoluble_____
Per cent of total bitumen insoluble in 86° B. naphtha_____
Fixed carbon_____
Residue of _____ penetration_____
Remarks: _____

Respectfully submitted,

_____
(Title) _____

(Name and location of laboratory:)

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REPORT ON SAMPLE OF TAR.

(Classification name of material.)

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Laboratory No. ----------

(Date reported.)

----------, 191__.

Trade name----------

Identification marks ----------

Submitted by---------- Title---------- Address----------

Sampled----------, 191__. Received----------, 191__.

Sampled from----------

Quantity represented----------

Manufactured by ----------

Location used or to be used----------

Examined for ----------

TEST RESULTS.

General characteristics----------

Water ----------

Specific gravity, 25° C./25° C----------

Specific viscosity, Engler at----------° C. ----------

Float test, ----------° C. (seconds)--------; --------° C. (seconds)--------

Melting point (° C)----------

Solubility in carbon disulphide----------

DISTILLATION.

| Fractions. | Character. | Per cent volume. | Per cent weight. |
|---|---|---|---|
| .....170° C | | | |
| 170° C.-235° C | | | |
| 235° C.-270° C | | | |
| 270° C.-300° C | | | |
| Residue | | | |

Specific gravity of distillate 25° C./25° C----------

Melting point of residue (°C)----------

Insoluble in dimethyl sulphate, per cent of fraction ____° C. to ____° C---------

Remarks:

Respectfully submitted,

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(Title)----------

(Name and location of laboratory:)

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REPORT ON SAMPLE OF PORTLAND CEMENT.

(Date reported.)

Laboratory No_____ _____, 191__.
Brand_____
Identification marks_____
Submitted by_____ Title_____ Address_____
Sampled_____, 191__. Received_____, 191__.
Sampled from _____
Quantity represented_____
Manufactured by _____
Location used or to be used_____
Examined for _____

TEST RESULTS.

Chemical tests:
- Loss on ignition, per cent_____
- Insoluble residue, per cent_____
- Sulphuric anhydride ($SO_3$), per cent____
- Magnesia (MgO), per cent_____

Physical tests:
- Specific gravity_____
- Per cent retained on 200-mesh sieve_____
- Steam test _____

| | Gillmore needle. | | Vicat needle. |
|---|---|---|---|
| Initial set_____ | _____ | or | _____ |
| Final set_____ | _____ | or | _____ |

Tensile strength (1:3 Ottawa sand):

| 7 days. | 28 days. |
|---|---|
| _____ | _____ |
| _____ | _____ |
| _____ | _____ |
| Average: _____ | Average: _____ |

Remarks:

Respectfully submitted,

_____
(Title)_____

(Name and location of laboratory:)

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REPORT ON SAMPLE OF VITRIFIED PAVING BRICK.

(Date reported.)

Laboratory No_____ _____, 191__
Trade name _____
Identification marks _____
Submitted by_____ Title _____ Address_____
Sampled _____, 191__ Received _____, 191__
Sampled from_____
Quantity represented_____
Manufactured by_____
Location used or to be used_____
Examined for _____

TEST RESULTS.

*General data.*

Average dimensions, length_____ Width_____ Depth_____
Drying treatment _____

*Standardization data.*

| | Weight of charge (after standardization. | Number of fresh stave liners. | Repairs affecting barrel. |
|---|---|---|---|
| 10 large spheres | | | |
| small spheres | | | |
| Total | | | |

Number of charges tested since last inspection, _____.

*Running data.*

| | Time readings. | | | Revolution counter readings. | Running notes, stops, etc. |
|---|---|---|---|---|---|
| | *Hours.* | *Minutes.* | *Seconds.* | | |
| Beginning of test | | | | | |
| Final reading | | | | | |

Initial weight of 10 bricks... ..... ..... .....
Final weight of 10 bricks.... ..... ..... .....
Loss of weight..... ..... ..... .....
Loss of weight, per cent.... ..... ..... .....
Number of bricks broken in test. ..... ..... .....

Maximum variation in per cent loss.

**Remarks:**

Respectfully submitted,

_____
(Title)_____

## RECOMMENDED STANDARD METHODS OF SAMPLING.

### Sampling Broken Stone.

(1) *By whom taken.*—Samples are to be taken by the engineer or his authorized representative.

(2) *When taken.*—Samples are to be taken from the proposed source of supply at least _____ days before the stone is to be accepted or rejected, also from every _____ cubic yards quarried, or when the quality or appearance of the stone changes, and at such other times as may be directed by the engineer.

(3) *Where and how taken.*—

(*a*) Sampling for quality: Samples shall be taken either from the quarry or from cars as directed by the engineer, and shall be sound interior rock, representative of that which it is proposed to use. Mixed samples may be taken if deemed necessary by the engineer.

(*b*) Sampling for size: Samples of the crusher product shall be taken either at the crusher or from cars as directed by the engineer. The sample shall be mixed from runs of the crusher, on different days, or, if taken from cars, shall be taken from both ends and top and bottom of the car.

(4) *Amount and size of sample.*—

(*a*) Sampling for quality: A sample shall weigh between 25 and 40 pounds and shall consist of pieces of rock at least $1\frac{1}{2}$ inches in size and one piece at least 3 by 4 by 6 inches, free from seams and cracks, and with bedding plane marked.

(*b*) Sampling for size: A sample for size shall weigh not less than 10 pounds for materials of three-quarters inch maximum diameter or less. Samples of materials of other sizes shall increase in weight to a maximum of approximately 60 pounds, varying with the size and weight of the largest pieces represented by the sample. The sample shall be representative of the product as delivered for use.

(5) *Marking and shipping.*—Samples shall be shipped in tight boxes or bags and shall be accompanied by a card in the container or securely attached thereto, stating date, by whom taken, by whom submitted, source of supply, exact location where sample was taken, proposed purpose to which the material is to be put, space for remarks, and in case of quarry investigations, owner, quantity available, amount and character of stripping, whether material from same source has been previously used, where and for what purpose, and with what results, haul to nearest point on road, average haul to job, character of haul, initial cost of rock.

Notification of sampling, containing the above data, shall be forwarded separately to the laboratory immediately upon taking the sample.

### Sampling Broken Slag.

(1) *By whom taken.*—Samples are to be taken by the engineer or his authorized representative.

(2) *When taken.*—Samples are to be taken from the proposed source of supply at least _____ days before the slag is to be accepted or rejected, also from every _____ cubic yards quarried, or when the quality or appearance of the slag changes, and at such other times as may be directed by the engineer.

(3) *Where and how taken.*—

(*a*) Sampling for quality: Samples shall be taken either from the deposit or from cars, as directed by the engineer, and shall be representative of that which it is proposed to use. Mixed samples may be taken if deemed necessary by the engineer.

(*b*) Sampling for size: Samples of the crusher product shall be taken either at the crusher or from cars as directed by the engineer. The samples shall be mixed from runs of the crusher on different days, or, if taken from cars, shall be taken from both ends and top and bottom of the car.

(4) *Amount and size of sample.*—

(*a*) Sampling for quality: A sample shall weigh between 25 and 40 pounds and shall consist of pieces of slag at least 1½ inches in size, and one piece at least 3 by 4 by 6 inches.

(*b*) Sampling for size: A sample for size shall weigh not less than 10 pounds for material of three-quarters inch maximum diameter or less. Samples of materials of other sizes shall increase in weight to a maximum of approximately 60 pounds, varying with the size and weight of the largest pieces represented by the sample. The sample shall be representative of the product as delivered for use.

(5) *Marking and shipping.*—Samples shall be shipped in tight boxes or bags and shall be accompanied by a card in the container or securely attached thereto, stating date, by whom taken, by whom submitted, source of supply, exact location where sample was taken, proposed purpose to which the material is to be put, space for remarks, and, in case of source investigations, owner, quantity available, whether material from the same source has been previously used, where and for what purpose, and with what results, haul to nearest point on road, average haul to job, character of haul, initial cost of slag.

Notification of sampling, containing the above data, shall be forwarded separately to the laboratory immediately upon taking the sample.

NOTE.—The conference, recognizing that in general slag is not a uniform product, recommends that special care should be taken to get a representative sample.

### SAMPLING STONE BLOCK.

(1) *By whom taken.*—Samples are to be taken by the engineer or his authorized representative.

(2) *When taken.*—Samples are to be taken at least _____ days before the block is to be accepted or rejected, or when the quality or appearance of the block changes, and at such other times as may be directed by the engineer.

(3) *Where and how taken.*—Samples shall be taken either from the quarry or from cars, as directed by the engineer. They shall be representative of the block which it is proopsed to use; and no sample shall include blocks that would be rejected by a visual examination.

(4) *Amount and size of sample.*—The sample shall consist of at least 10 blocks. The bedding plane shall be marked on at least 2 blocks.

(5) *Marking and shipping.*—Samples shall be shipped in tight boxes and shall be accompanied by a card in the container, or securely attached thereto, stating date, by whom taken, by whom submitted, source of supply, exact location where sample was taken, proposed purpose to which the material is to be put, whether material from same source has been previously used, where and for what purpose and with what results, initial cost of block, haul to nearest point on road, average haul to job, character of haul, and space for remarks.

Notification of sampling, containing the above data, shall be forwarded separately to the laboratory immediately upon taking the sample.

### Sampling Gravel.

(1) *By whom taken.*—Samples are to be taken by the engineer or his authorized representative.

(2) *When taken.*—Samples are to be taken from the proposed source of supply at least _____ days before the gravel is to be accepted or rejected, also from every _____ cubic yards excavated, or when the quality or appearance of the gravel changes, and at such other times as may be directed by the engineer.

(3) *Where and how taken.*—

(*a*) Sampling at the pit: Enough samples shall be taken to represent an average of the material. An individual sample must be taken through a full vertical section of that material which it is proposed to use at the point selected. Each sample shall be taken from a freshly exposed vertical face.

(*b*) Sampling from cars, barges, etc.: Enough samples shall be taken, as directed by the engineer, to represent average composition. Samples from cars shall be taken from both ends and from top and bottom of the car.

(4) *Amount and size of sample.*—

(*a*) Sampling for quality: For screened gravel sample shall weigh 25 to 30 pounds. For bank gravel sample shall weigh 50 to 75 pounds.

(*b*) Sampling for size: A sample for size shall weigh not less than 10 pounds for materials of three-quarter-inch maximum diameter or less. Samples of materials of other sizes shall increase in weight to a maximum of approximately 60 pounds, varying with the size and weight of the largest pieces represented by the sample. The sample shall be representative of the product as delivered for use.

(5) *Marking and shipping.*—Samples shall be shipped in tight boxes or bags and shall be accompanied by a card in the container or securely attached thereto, stating date, by whom taken, by whom submitted, source of supply, exact location where sample was taken, proposed purpose to which the material is to be put, space for remarks, and, in case of pit or bank investigation, owner, quantity available, amount and character of stripping, whether material from same source has been previously used, where and for what purpose, and with what results, haul to nearest point on road, average haul to job, character of haul, initial cost of gravel.

Notification of sampling, containing the above data, shall be forwarded separately to the laboratory immediately upon taking the sample.

### Sampling Sand.

(1) *By whom taken.*—Samples are to be taken by the engineer or his authorized representative.

(2) *When taken.*—Samples are to be taken from the proposed source of supply at least _____ days before the sand is to be accepted or rejected, also from every _____ cubic yards excavated, or when the quality or appearance of the sand changes, and at such other times as may be directed by the engineer.

(3) *Where and how taken.*—Samples shall be taken from freshly exposed portions of the deposit as directed by the engineer. Mixed samples may be taken if deemed necessary.

In general, the number of samples shall be sufficient to cover the extreme variation of quality in that part of the deposit which is proposed to be used.

(4) *Amount and size of sample.*—Each sample, whether individual or composite, shall weigh between 10 and 15 pounds.

(5) *Marking and shipping.*—Samples shall be shipped in tight boxes or bags and shall be accompanied by a card in the container or securely attached thereto, stating date, by whom taken, by whom submitted, source of supply, exact location where sample was taken, proposed purpose to which the material is to be put, space for remarks, and in case of source investigation, owner, quantity available, amount and character of stripping, whether material from same source has been previously used, where and for what purpose, and with what results, haul to nearest point on road, average haul to job, character of haul, initial cost of sand.

Notification of sampling, containing the above data, shall be forwarded separately to the laboratory immediately upon taking the sample.

### Sampling Semi-Gravel, Top Soil, and Sand Clay.

Samples of materials of this class shall be of two kinds: Class I, samples of the raw material taken from the natural deposit; Class II, samples of the loose material after being mixed in place on the roadbed and before consolidation.

Class I sample shall be used simply as preliminary evidence of the suitability of the aggregate subject to admixture of one or more ingredients to adjust the composition to the limits set forth in the specifications.

The final acceptance of the material as satisfying the specifications shall be based on Class II samples.

*Standard containers.*—(1) A three-compartment box of pasteboard, wood, or metal, outside dimensions 5 by 10 by 10 inches; or (2) close woven bags or sacks of material which do not allow sifting out of fine particles, dimensions 6 inches wide by 12 inches long.

*Labeling.*—Each compartment in the box container must contain a label showing at what depth the contents were taken. The whole sample shall be accompanied by a card, securely attached thereto, stating date, by whom taken, by whom submitted, source of supply, exact location where sample was taken, position within the deposit where taken, owner, quantity available, amount and character of stripping, if any, whether material from same source has been previously used, where, and with what results, haul to nearest point on road, average haul to job, character of haul, initial cost of material.

When bag containers are used, one complete sample shall comprise 3 bags, each bag labeled as to depth from which the material is taken.

Each bag, or, if preferred, a larger receptacle containing the three bags, is to be labeled with the information detailed above.

*How to take Class I samples.*—For each 1 acre or less of area two samples must be taken, one a local sample and the other a composite sample.

The local sample is to be taken near the center of the area and is intended to represent the vertical average of the material at that point. It shall be taken in three layers, each layer ____ inches thick, according to the method described as follows:

The material is to be loosened over a 3 by 3 foot area to the specified depth, usually 4 inches. The loose material is to be intermixed with a shovel and the sample for one compartment of the box container or one of the bags is to be taken therefrom.

The remaining loose material is to be shoveled out and discarded. The second layer is to be loosened to equal depth, usually 4 inches, to be intermixed as before, and a second compartment or bag is to be filled. The same procedure shall apply to the third layer, and the filling of the third compartment or bag.

In exceptionally thick deposits the depth of each layer or the number of layers may be increased to cover the entire thickness of the deposit.

The composite sample is to be taken as follows: Roughly divide the area to be represented by the sample into squares not exceeding 50 feet in size. At the corners of all squares loosen a 3 by 3 foot area to a depth of ____[1] inches. Thoroughly mix the loose material. Carry an equal amount of the material from each such point to a central point and intimately mix the various samples. Not less than 200 pounds of material must be so mixed. From the center of the pile of mixed material fill a container and label for shipment.

Where the material occurs as a substratum sink no less than four 3 by 3 foot pits per acre or smaller area to intersect the material. Remove the covering and sample the exposed bed as for a local sample described above.

*How to take Class II samples.*—These are the most important samples, and should be taken by the engineer or competent inspector while work is in progress.

When the materials have been spread and intimately mixed in accordance with properly drawn clauses covering methods of construction, the engineer should fill a container at intervals of ———[2] feet, along the road, and also at such other points as his judgment may dictate, where evidence of unsatisfactory mixing is apparent.

Very prompt examination of these samples should be made in order that defects of composition may be remedied by the builder before consolidation has progressed.

### Sampling Bituminous Materials.

*General recommendations.*—All samples should be selected to represent as nearly as possible an average of the material, care being taken that they are not contaminated with other materials. It is recommended also that special care be taken to forward the samples in clean, suitable containers, and wherever possible all materials should be sampled at the point of manufacture, and sufficiently in advance of shipment of the material represented to allow for the testing and reporting upon the sample before shipment. When impracticable to take samples at the point of manufacture they should be taken by the engineer or inspector, from the shipment immediately upon delivery.

In collecting samples, if there is any doubt of the homogeneity of the material it is recommended that individual samples be lifted as hereinafter described, and such samples should be forwarded to the laboratory, where tests should be conducted to determine the uniformity, after which a composite sample of equal parts of the individual samples may be mixed for complete tests.

Samples should be taken as frequently as necessary to insure the uniformity of the material.

*Marking samples.*—Samples should be marked for identification in such manner that the identification will not be removed in transit. Notification of sampling containing this identification, together with such other information as is required or of advantage to the laboratory, should be separately forwarded to the laboratory immediately upon taking the sample.

*Size of samples.*—No sample should be less than 1 quart, whether for complete testing or for individual test.

*Plant sampling.*—Drip samples are recommended. In taking drip samples, the pumping should be continued until sufficient time has elapsed to clean the line before sample is taken. The drip valve should be so regulated that the collecting of the material continues through the entire time of pumping.

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[1] A depth of 8 inches is suggested. [2] Intervals of 500 feet are suggested.

When impracticable to follow the above method it is recommended that samples be taken from the storage tank at three different levels.

Material in barrels or drums at a plant should be sampled by taking samples from not less than 3 per cent of the containers.

Whenever possible, the portion of the sample from each drum or barrel should be taken from near the heart of the barrel after it has been split open. Where samples must be taken from the top of the barrel, the material lying within three inches of the surface should not be included. A hatchet or any sharp-pointed tool is suitable for the purpose of digging into the barrel. (IMPORTANT.—Do not use kerosene on the blade.) The several portions are then to be pressed in a can of not less than one-quart capacity, using enough material very nearly to fill the can which is then tightly covered. If cans are not available and some other type of container used, they must be entirely free from paper or any other substance to which the bituminous material adheres readily.

Check field samples are recommended on plant inspected material.

*Field sampling.*—For barrel shipments, see plant barrel sampling.

*Sampling fluid products.*—When a fluid material is shipped in tank cars, and the sample is to be taken directly from the tank car to represent an average of the entire tank-car contents, the following method is suggested:

A tin can, with a tight-fitting removable cover and a wire handle, is secured, and a number of holes one eighth of an inch in diameter are punched in the cover. This bucket is then weighted in any convenient way and lowered slowly by means of a cord attached to the handle through the entire depth of the tank car, so that the can will be filled with material from all depths of the car. This can is then emptied into another can of at least 1 quart capacity having a screw top or other equally tight cap or cover. A sample is more representative when the tank car has been agitated before the sample is taken.

Where individual samples are desired to check the uniformity of material throughout a tank car, it is suggested that thief samples be taken from top and middle and a third sample be taken from the outlet valve through which a sufficient amount of bituminous material has been allowed to flow in order to clean the valve properly.

*Semisolid products.*—Barrel shipments are to be sampled as in plant sampling.

Tank-car shipments are to be sampled through the dome by the use of a clean hot shovel.

*Bituminous aggregates.*[1]—It is suggested that a 5-pound sample be submitted when the material is sampled before being placed in the pavement.

Samples of pavements should be at least 1 square foot.

The material should be carefully boxed in order that it may remain intact during transit.

### SAMPLING PORTLAND CEMENT.

Each shipment or lot of cement used on the work shall be sampled and tested in accordance with the standard specifications and tests for Portland cement given in the 1916 standards of the A. S. T. M. serial designation C9–17.

It is recommended that in sampling cars and bins the method specified in A. S. T. M. 1916 standard specifications for Portland cement, section 17 (*b*)

[1] The term "bituminous aggregate" is defined as follows: The mineral or other aggregate, together with the bitumen which is used as the cementing medium.

be followed, using composite samples. Samples at the mill shall be taken by any of the methods of section 18, A. S. T. M. specifications, as may be most practicable.

### Field Samples of Concrete.

(1) *When taken.*—Samples shall be taken regularly for the general control of strength and uniformity on one day of each week of work; and at irregular intervals, whenever a complete change is noted in the character or grading of one or more materials or in any element affecting the entire mix.

(2) *Number of samples.*—

(*a*) In taking regular samples three specimens should be molded to be broken one at each of the periods, 14 days, 28 days, and _____.

(*b*) In taking irregular samples, nine specimens should be molded, three to be broken at each of the periods, 14 days, 28 days, and _____.

*How taken.*—The batch sampled for general purpose should be similar in consistency and general grading of the aggregate to the regular run of batches being turned out. The sample from which specimens are molded should be composed of several portions taken during the discharge of one batch in order to represent an average of the batch; or the batch may be dropped upon the subgrade and concrete from several points (taking care to exclude dirt), placed in a clean wheelbarrow or other container, avoiding additional mixing.

### Sampling Vitrified Paving Brick.

*Inspection.*—Vitrified brick may be inspected and tested at the point of manufacture, or they may be sampled at the point of delivery, and representative samples submitted to the laboratory for testing prior to acceptance of the shipment.

*Plant inspection.*—Whenever practicable the inspection and testing of vitrified brick shall be carried on at the manufacturer's plant. The choice between plant inspection and sampling at point of use should be based on the average number of brick to be shipped from the plant per day, and the total number required for the particular piece of work.

Whenever conditions permit, samples should be taken directly from the kiln during the process of emptying. One or more sets of tests, depending upon the size of the kiln, each set consisting of three separate tests, should be made on each kiln. Each test in a set of three should represent approximately a single degree of burning (based on the position of the bricks in the kiln), and all ten of the bricks in a single test should be of the same approximate degree of burning.

The average abrasion loss in three such tests will determine whether the contents of a kiln or part of a kiln meet the average maximum abrasion loss specified; and the maximum variation between the per cent abrasion losses of the three sets will be used to determine what portion of the bricks represented will be culled or rejected.

*Sampling from piles at the plant.*—In general, samples selected from piles at the plant shall be as nearly as possible representative of the entire run of the brick. Samples from piles shall be taken from as many different points corresponding to the length, breadth, and depth of the pile as possible. In no case shall they be confined to the upper or outer few layers. Where controversy arises regarding the admissibility of certain types or portions of the lot, entire test samples may be selected from such types or portions having a characteristic appearance in common.

*Sampling at point of delivery.*—A representative sample should be taken from each carload received. Considerations covered under "Sampling from piles at the plant" apply equally to sampling from cars.

*Shipping.*—Samples shipped by freight or express to the laboratory shall be put up in packages containing twelve bricks each, packed in two rows separated by a partition for protection.

*Condition of bricks before testing.*—If bricks are damp, they shall be dried at a temperature of 100° F. before testing. No bricks shall be included in the test lot which would be rejected on the basis of cracks, chips, or other defects covered by the specification clauses for visual inspection.

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